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THE

INSTITUTIONS

OF

PHYSIOLOGY

BY

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TRANSLATED FROM THE LATIN OF THE THIRD AND LAST EDITION,

AND SUPPLIED

WITH COPIOUS NOTES,

BY

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THIRD EDITION, CONSIDERABLY IMPROVED.

Quæramus optima, nec protinus se offerentibus gaudeamus; adhibeatur judicium inventis, dispositio probatis.

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TO

HIS ROYAL HIGHNESS

PRINCE AUGUSTUS FREDERICK

DUKE OF SUSSEX,

EARL OF INVERNESS,

Baron of Arklow,

KNIGHT OF THE MOST NOBLE ORDER OF THE GARTER,

&c. &c. &c. &c.

THE STRENUOUS SUPPORTER OF EVERY THING WHICH CAN
EXALT THE CHARACTER OR AUGMENT THE
HAPPINESS OF MANKIND,

AND

THE FRIEND OF PROFESSOR BLUMENBACH,

THE FOLLOWING PAGES

ARE,

WITH HIS ROYAL HIGHNESS'S PERMISSION,

MOST RESPECTFULLY INSCRIBED.

THE TRANSLATOR'S

PREFACE.

In expressing the gratification which I must feel at a third edition of my Work being so soon required, I have also to express my regret that peculiar circumstances have compelled me to leave it so many months out of print.

The Translation will be found revised, innumerable errors of various descriptions corrected, every accession of physiological knowledge up to the present moment inserted, several points fully discussed which before were too briefly noticed, and consequently the amount of my Notes very considerably increased.

Many inadvertencies will no doubt still be discovered, and so far from being displeased I shall be grateful to have them pointed out, as well as to have my opinions freely examined. For I should blush to be reluctant in allowing to others what I always claim myself,—*sentire quæ velim*, *et dicere quæ sentiam.* Truth is my object, and, though I have become a writer, my disposition is really *discere libentius quam dicere.*

The lapse of ten years since the last publication of Professor Blumenbach's work, no less than since that of M. Richerand's, has compelled me to supply notes of correction as well as of addition, and will excuse me for differing on some points from my celebrated and venerable author, without urging what is universally allowed,—that, when a dwarf gets on the shoulders of a giant, he may see farther than the giant himself.

Whatever is peculiar and excellent in M. Majendie's Physiological work, has been carefully transferred, so that my readers will, I trust, possess not only a full and faithful statement of the Physiological Science of the present time, but enjoy the advantage of a sort of triple work by a German, a Frenchman, and an Englishman.

15, *Grafton Street, Bond Street,*
April 8, 1820.

THE AUTHOR'S PREFACE

TO THE

LAST EDITION.

WHENEVER my booksellers have informed me that a new edition of any of my works was required, I have always gladly seized the opportunity of correcting inaccuracies arising either from carelessness or the imperfections of human nature, and of adding in some places and altering in others; in short, of sending forth the production of my abilities in a more finished state.

In preparing this new edition of my INSTITUTIONS of PHYSIOLOGY for the press, the same anxious wish has been considerably heightened by the importance of the subject, and by the approbation evidently bestowed upon the last edition, from its translation into our own language, into Spanish, French, English,* Dutch, and Russian; not to mention other proofs of its favourable reception. I have endeavoured, therefore, to enrich it not so much with an addition of pages, as of various matter; to arrange the heads in a more natural order; and to render the whole as useful to students as possible.

September 10, 1810.

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* I am unable to discover any English translation besides my own, which was first published in 1815.—J. E.

THE AUTHOR'S PREFACE

TO THE

FIRST EDITION.

THE same considerations which led Boerhaave, and after him Haller, to write their Compendiums of Physiology, induced the Author to compose these Institutions.

The former says, "that a teacher succeeds better in commenting upon his own thoughts, than upon a work written by another:—that his doctrine will be clearer, and his language generally animated," &c. *

The latter, "That, although he formerly used Boerhaave's work as a text-book, he afterwards

* Pref. to the *Institut. Medic.* Leyden. Fourth edition.

lectured upon one written by himself, because anatomy had been so improved since the time of Boerhaave, as to have become almost a new science." *

What Haller said at that period respecting anatomy, will be allowed to apply much more forcibly at present to physiology, by any one who considers the most important parts of the science,—the principal purpose of respiration, animal heat, digestion, the true nature and use of the bile, the function of generation, &c.

More, therefore, must be ascribed to the age than to the author, if in these Institutions, after so many modern physiological discoveries, he delivers doctrines more sound and natural than it was in the power of his most meritorious predecessors to deliver.

Whatever he can claim as his own, whether really new or only presented in a new view,

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* Pref. to the *Prim. lin. Physiol.* Gottingen. First edition.

will be easily discovered by the learned and impartial reader; especially from the notes, in which he has treated some of these subjects rather more minutely than, in the text, was compatible with the conciseness of his plan.

He has been at great pains in arranging the subjects, so that the sections might succeed naturally and easily, and arise, as it were, one out of another.

He has not quoted a dry farrago of books, but a select number, in doing which, he has wished both to point out to students some excellent authors not commonly known, especially those who have professedly treated on particular branches of the subject, and to open, besides medical sources of information, others not yet applied, he conceives, to Physiology as they deserve.

His grand object has been to deliver, in a faithful, concise, and intelligible manner, the principles of a science inferior in beauty, importance, and utility, to no part of medicine, if the words prefixed by the immortal Galen to his *Methodus Medendi*, are true, as they most certainly are:—"The magnitude of a disease is in proportion to its deviation from the healthy state; and the extent of this deviation can be ascertained by him only who is perfectly acquainted with the healthy state."

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CORRIGENDA.

Page 34, last line, *for* E *read* F.
Page 49, last line, *for* ? *mark* !
218, *for* Ottomans *read* Ottomacs.
—— last line, *for* it *read* earth.

THE INSTITUTIONS OF PHYSIOLOGY.

SECT. I.

OF THE LIVING HUMAN BODY IN GENERAL.

1. In the living human body, regarded as a peculiar organisation, there are three objects of consideration.*

The materials of its subsistence, afforded by the fluids;

The structure of the solids, containing the fluids;

Lastly, and principally, *the vital powers*, by which the solids are enabled to receive the influence of the

* Thus, long ago, the author of the book generally included among the writings of Hippocrates, *Epidemic*. VI. Sect. 8. § 19. said, "Those things which contain, are contained, or moved in us with force, are to be considered." This celebrated passage gave origin to the excellent work of Abr. Kaau Boerhaave, entitled, "*Impetum faciens dictum* Hippocrati *per corpus consentiens*." L B. 1745. 8vo.

fluids—to propel the fluids—and perform various other motions; and which, as they, in a certain sense, constitute the essence of the living machine in general, so also are of very different orders—some being common to animals and vegetables—some peculiar to animals and intimately connected with the mental faculties.

2. But these three, although really distinct, and therefore distinctly considered by us, are so closely related in the *living* system, (the phenomena, conditions, and laws of whose functions, in the healthy state, are the object of physiology) that no one can be contemplated but in its relation to the rest.

For the materials of the body, although originally fluid, are naturally disposed to become solid; and, on the other hand, the solids, besides having been formed from the fluids, abound, however dry they may appear, in various kinds of fluid constituents, both liquid and aëriform: lastly, it may probably be affirmed, that no fibril, during life, is destitute of vital power.

3. We shall now examine each of these separately; and first, the materials afforded by the fluids, which form both the fundamental and most considerable portion of our bodies.*

* The great preponderance of the fluids is strikingly exemplified in an entire, but perfectly dry, mummy of an adult Guanche, one of the original inhabitants of the island of Teneriffe. It was sent to my anatomical museum by the illustrious Banks, and, though all its viscera and muscles are preserved, does not exceed 7½lbs. in weight.

SECT. II.

OF THE FLUIDS IN GENERAL, AND PARTICULARLY OF THE BLOOD.

4. The fluids of the body may be conveniently reduced to three classes.

A. The *crude;* viz. the chyle, contained in the primæ viæ and destined to become blood; and matters absorbed on the surface and destined to be conveyed to the chyle.

B. The *blood* itself.

C. Those *secreted* from the blood, whether inert and excrementitious, like the urine; or intended for certain purposes in the economy: the latter may be permanently liquid, as the bile; or disposed to solidity, as the osseous and other plastic juices.

5. Of the first and third of these classes we shall hereafter speak, in treating of chylification, secretion, and the other functions to which each fluid appertains. At present our attention shall be devoted to the *blood* *—the chief and primary fluid—the vehicle of those successions of oxygenous and carbonaceous particles, which cease with life only—the nourisher of the frame—the source of almost every fluid—that *into* which the crude fluid is converted and *from* which all the secretions are derived—and which, with the exception of some exsangueous parts, as the epidermis, the arachnoid, the amnion, &c. the vitreous substance of the

* J. Hunter, *Treatise on the Blood, Inflammation,* &c. London, 1794. 4to.

teeth, the body of the crystalline lens, &c. is universally diffused through the system, in various proportions, indeed, according to the various natures of the similar parts, to use the language of the ancients,* v. c. abundantly in the muscles and glands, sparingly in the tendons and cartilages.† (A)

6. The blood is a fluid *sui generis*, of a well known colour and peculiar odour; its taste is rather saline and nauseous; its temperature about 96° of Fahrenheit; it is glutinous to the touch; its specific gravity, though different in different individuals, may be generally estimated as 1050, water being 1000; when fresh drawn, and received into a vessel, it exhibits the following appearances.‡

7. At first, especially while still warm, it emits a vapour which has of late been denominated an animal gas and shewn to consist of hydrogen and carbon, suspended by caloric.§ This, if collected, forms drops

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* They divided the body into *similar* or homogeneous parts, as the bones, cartilages, muscles, tendons, &c.; and *dissimilar*, composed of the similar, as the head, trunk, limbs, &c.

† Physiologists have variously estimated the quantity of blood in a well formed adult. Allen, Mullen, and Abildgaard, make it scarcely more than 8 pounds; Borelli, 20; Haller, 30; Hamberger, 80; J. Keil, 100. The former are evidently nearer the truth.

‡ J. Martin Butt, *De spontanea sanguinis separatione.* Edinb. 1760. 8vo. reprinted in Sandifort's *Thesaurus.* vol. ii. J. H. L. Bader, *Experimenta circa sanguinem.* Argent. 1788. 8vo.

§ The *elements* of aëriform fluids of course exist in the blood; that they are not, however, in the *elastic state*, as so many physiologists formerly believed, was clearly shewn in some experiments made by me during the year 1812, upon other mammalia. I found that a small portion of the purest air infused into the jugular vein, excited palpitations, drowsiness, convulsions; and if the quantity was rather increased, even death ensued. I have detailed these experiments in the *Medic. Biblioth.* vol. i. 177. The illustrious Bichat observed the same effects in his experiments. *Journal de Santé, &c. de Bourdeaux.* t. ii. p. 61.

resembling dew, of a *watery* nature, but affording a nidorous smell, which is most remarkable in the blood of carnivorous animals, peculiar and truly animal. Much of this watery liquor still remains united with the other parts of the blood. (B)

8. In the mean time the blood, when its temperature has fallen to about 78°, begins to separate into two portions. A coagulum is formed, from the surface of which exudes, as it were, a fluid of a yellowish slightly red colour, denominated *serum:* the more abundantly this exudes, the greater is the contraction of the glutinous coagulum, which has received the appellations of *crassamentum;* and, from some resemblance to the liver in colour and texture, of hepar sanguineum; of placenta; and, from the circumstance of its being surrounded by the serum, of insula. (C)

9. The crassamentum may, by agitation or repeated ablution, be easily separated into two constituent parts—the *cruor,* which imparted to the blood its purple colour, and the *lymph,* which on washing is forsaken by the cruor, and called, from its greater solidity, the basis of the crassamentum. The stronger affinity of the cruor for the lymph than for the serum, is proved by the necessity of violence to effect their disunion. By the removal of the cruor the lymph becomes gradually paler, till it is at length merely a white tenacious coagulum. (D)

10. Besides the watery fluid first mentioned, these are the three constituents of the blood, viz. the *serum,* the *cruor,* and the *lymph:* we shall presently treat of each more particularly. These, however, while recent, and in possession of their native heat, are intimately

mixed, and form an equable, homogeneous fluid. Their relative proportion is astonishingly diversified, according to age, temperament, diet, and similar circumstances which constitute the peculiar health of each individual.

11. The *serum* is a peculiar fluid, the chief cause of the viscidity of the blood, and easily separable by art into different constituent principles. If subjected to a temperature of 150° Fahr. a portion is converted into a white scissile substance, resembling boiled *albumen:* the rest exhibits, besides the watery fluid so often mentioned, a turbid fluid of a *gelatinous,* or rather *mucous,** nature, which on cooling appears a tremulous coagulum. The serum is remarkable for the quantity of soda (mineral alkali) which it contains. (E)

12. The *cruor* has many peculiarities, in regard to both the colour and the figure of its particles. It consists of *globules,* which in recent blood are of a constant form and size, and said to be $\frac{1}{3300}$ of an inch in diameter. Their form, indeed, has been a subject of dispute; but I am disposed to consider it as much more simple than some writers of great celebrity have imagined. I have always found it globular, and could never discover the lenticular shape which some have asserted that they remarked.

It has been likewise advanced, that the globules change their form, while passing through a vessel of very small capacity—that, from being spherical, they become oval; and, when they have emerged into a

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* J. Bostock, *Medico-Chirurgical Transactions, published by the Medical and Chirurgical Society of London.* vol. i. 1809. p. 46.

vessel of larger area, that they again resume their globular shape.* This, although I would by no means deny it, I cannot conceive to occur during the tranquil and healthy motion of the blood, but should refer it to a spasm of the small vessels.

Their globular figure can be seen in a living animal only, or in blood very recently drawn: for they are soon unobservable, becoming a shapeless mass which resembles serum in every circumstance excepting colour.

13. Their *colour* is red, and from it is derived the colour of the blood. In intensity it varies infinitely; paler in animals which have been poorly nourished or have suffered from hæmorrhage; more florid, when oxygenised † (rendered arterial, to use the common phrase) by exposure either to atmospheric air, or, more especially, to oxygen; darker when carbonised, (in common language, rendered venous) by exposure to carbonic acid gas, or to hydrogen.‡ The redness is

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* G. Chr. Reichel, *De sanguine ejusque motu Experimenta.* Lips. 1767. 4to. p. 27. fig. 3. g. g.

† Unwilling as I am to follow the example of those, who, especially in modern times, delight in changing scientific terms, I cannot but think that the words *oxygenised* and *carbonised* may be advantageously substituted for arterial and venous: because arterial blood is contained in some vessels called *veins*, v. c. the pulmonary and umbilical; while, on the other hand, venous blood is contained in the pulmonary and umbilical *arteries*. In the same manner, the veins of the chorion in the incubated egg contain arterial, the arteries, venous, blood;—to use these expressions in their common acceptation.

‡ Consult among others whom we shall recommend in the chapter on respiration, Chr. Girtanner, *Journal de Physique*. August. 1790.

Fourcroy, *Annales de Chimie*. t. vij.

Hassenfratz, ibidem. t. ix.

J. Ferd. H. Autenreith, *Experimenta et observata de sanguine præsertim venoso*. Stuttg. 1792. 4to.

most probably to be ascribed to the oxide of iron,* the quantity of which, however, is so minute, that it has been most variously estimated. (F)

14. The last constituent principle of the blood to be noticed, is the plastic *lymph*, formerly confounded with the serum. This has been called the basis of the crassamentum, the glutinous part, the fibre or fibrous matter of the blood, and, like the caseous part of milk and the gluten of vegetables, been discovered by late analysis to abound in carbon and azote. (G)

15. It is properly denominated plastic, because it affords the chief materials from which the similar parts, especially the muscles, are immediately produced; nourishes the body throughout life; repairs wounds and fractures in an extraordinary manner; fills up the areæ of large blood vessels when divided; and forms those concretions which accompany inflammations,† and that remarkable deciduous membrane found in the recently impregnated uterus for the attachment of the ovum.

16. Thus much have we said, respecting the constituent parts and nature of the blood, the most important fluid of the animal machine,—a fluid, which *excites the heart* to contraction; which distributes *oxygen* to every part, and conveys the *carbon* to the excretory vessels, giving rise, by this change, to *animal heat;* which sup-

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* By Will. C. Wells, *Philos. Trans.* 1797, the redness of the blood in general is rather ascribed to the peculiar structure of the globules, and its various degrees and changes simply to the reflection of light.

† Such are those *spurious membranes* found exuded on the surface of inflamed viscera, v. c. those cellular connections between the lungs and pleura after peripneumony, and the tubes observed within the bronchiæ after croup: such also are those artificial ones called, after their inventor, Ruyschian, and made by stirring fresh blood about with a stick.

plies the *materials* of the *solids* originally, and afterwards their *nourishment;* and from which all the *other fluids,* with the exception of the crude (4.), are *secreted* and derived. Of the multifarious importance of the blood, we shall speak particularly hereafter.

NOTES.

(A) The blood is now known not to absorb any oxygen during ordinary respiration. See note (C.) Sect. viii.

(B) When blood, venous or arterial, is placed in the vacuum of an air-pump* or coagulates in the air,† it emits a considerable quantity of carbonic acid gas: in a paper lately read to the Royal Society, but not yet printed, the quantity is said to be much greater after a meal, and much less if the blood is buffy.

(C) Blood coagulates when cut off from communication with the mass by escape from its vessels, whether warm or cold, in the air or in vacuo, diluted or undiluted, at rest or in motion; whereas within the vessels, rest, which causes a cessation of intercourse between the motionless portion and the general mass, is in many cases sufficient to effect its coagulation. After death from a blow on the stomach, lightning, arsenic, hard running, &c. it does not coagulate.‡

(D) To suppose any affinity of the red particles for either the lymph or the serum is erroneous. Leeuwenhoek and Hartsoeker long since proved that serum merely suspends them, for if, when separated, they are triturated in some serum, part of them is taken up and the serum assumes a red colour; but if the fluid is allowed to settle in a cylindrical glass, they slowly precipitate themselves to the bottom, and the serum above becomes clear, as before. When blood is drawn, the *serum* easily separates on the coagulation of the lymph. But the *lymph* coagulates before

* *Annales de Chimie.* xiii. † *Phil. Trans.* 1818. p. 181.

‡ Hunter *on the Blood, &c.*

the colouring particles have time to fall to the bottom, and entangling them acquires a red colour, forming the crassamentum: if, however, the lymph coagulate slowly, as in the phlogistic diathesis, the greater specific gravity of the cruor detaches it very considerably from the lymph, which remains colourless above, constituting what is called the inflammatory coat, crust, or buff.* Berzelius even believes the lymph to be in a state of solution in the serum, while the cruor is simply suspended in this solution; but the separation of the serum in dropsy, vesication, &c. led Mr. Hunter to a different conclusion.†

(E) The coagulable part of serum is albumen; that which remains fluid is called serosity,—a name given it by Cullen, and contains no gelatine as the French chemists asserted, but an animal matter different from both gelatine and albumen, with a minute portion of albumen and fibrine, and affords a little free soda, muriate, lactate,‡ and phosphate, of soda, and muriate of potash, with $\frac{905}{1000}$ of water.§ If mixed with six parts of cold water, serum does not coagulate by heat.

(F) When *venous* blood acquires a florid colour by exposure to oxygen or atmospheric air, (and it does so even when covered by a bladder) carbonic acid gas is formed, and an equal quantity of oxygen gas disappears. If exposed to nitrous oxide, it becomes of a brighter purple, and much of the gas is absorbed: carbonic acid gas renders it darker and is a little absorbed, while azote occasions no change. The dark colour produced in arterial blood by carbonic acid or azotic gas takes place if blood is placed in

* In this state the albumen of the serum is also affected, for it does not coagulate by heat as usual, and the whole mass of blood is thinner.

† *View of the present State and Progress of Animal Chemistry* by Jöns Jacob Berzelius, M. D. &c. Translated by Dr. Brunnmark. 1813. p. 23. Hunter, l. c. p. 18.

‡ Berzelius discovers lactic acid free or combined in all animal fluids. It was first noticed by Scheele, but is generally regarded as a combination of acetous acid with animal matter.

§ See Dr. Bostock's papers in the first, second, and fourth volumes of *The Medico-Chirurgical Transactions*, and Berzelius's in the third.

vacuo, though less rapidly and deeply than if exposed to hydrogen gas. Arterial blood left in contact with oxygen gradually acquires the same dark colour, and no oxygen will afterwards render it scarlet. Berzelius finds the colouring particles only concerned in these changes, and, after all, no difference of composition can be detected between scarlet and purple blood.

It has been generally supposed that iron exists in the red particles of the blood as a subphosphate. Berzelius informs us that serum, although able to dissolve a small portion of the oxides, not indeed of the phosphates, of iron, does not acquire a red colour by their addition, and that he has never discovered iron nor lime in the entire blood, although both are so abundant in its ashes. He concludes that the blood contains the *elements* of phosphate of iron and of lime, and of carbonate of lime, and also of phosphate of magnesia, united in a manner different from their combination in the salts.

Mr. Bauer, whose microscopic skill is effecting so much for anatomy and physiology, finds that the globules consist of a colourless nucleus and an enveloping coloured portion,* as Dr. Young first discovered.† A nucleus is about $\frac{1}{5000}$ of an inch in diameter, and the whole globule nearly one-fourth larger. In the unpublished paper above quoted, it is further stated that Mr. Bauer has discovered a third set of smaller colourless globules in the blood, $\frac{1}{2800}$ of an inch in diameter. They appear to belong to the fibrine, and Sir Everard Home accordingly denominates them lymph globules. Colourless globules gradually form also in serum.‡ Oxygen and hydrogen also exist in fibrine.

(G) The fibrine, albumen, and colouring matter, afford, on decomposition, the same saline and gaseous products. Berzelius views them all three as modifications of the same substance. Albumen contains a greater proportion of oxygen than fibrine, and has sulphur for a constituent part, which, however, cannot be detected while the albumen is entire, any more than the iron while

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* *Phil. Trans.* 1818. p. 187. † *Medical Literature*, p. 545.

‡ *Phil. Trans.* 1819. p. 2, sq.

the cruor is entire. The chief differences between the colouring matter and fibrine are, colour, the spontaneous coagulation of fibrine at all temperatures while the colouring matter may be dried without losing its solubility in water and becomes insoluble only at a certain temperature, and the peculiarity in the latter of not diminishing in volume like fibrine during exsiccation. Albumen is intermediate between the two, and its only character of distinction from fibrine is that it does not coagulate spontaneously, but requires a high temperature. The brain and crystalline lens are a sort of albumen; the epidermis, nails, hair, horn, cartilage, are nearly composed of it; of bone and muscle it is an essential part. Fibrine exists in muscles only, besides the blood, and is indeed their chief constituent, giving them form and rendering them fibrous. Gelatine, or rather what becomes so by the agency of boiling water, contains somewhat less carbon and more hydrogen than albumen, and although not obtained from blood, is an important part of our frame: the cutis, serous membranes, and tendons, are a species of it, it forms the chief part of cellular membrane, and is an essential constituent of bones, muscles, ligaments, hair, &c. The composition of the substance of the viscera is not well known.

The blood of brutes has the same general character as our own, but Berzelius finds a larger proportion of nitrogen in that of the bull, and by analogy I should think there must be a peculiarity in the blood of every species. Muscles look pretty much alike in various animals, yet our dishes disclose the greatest diversities. Transfusion, or pouring the blood of one system into another, has been practised for a century and a half, and satisfies us that the blood, whether arterial or venous, of one individual, agrees well enough with another of the same species; but some late experiments of Dr. Leacock,* and subsequently of Dr. Blundel,† render it unlikely, contrary to the opinion of former experimentalists, that the blood of one species suits the system of another. Dr. Young found the large outer globules of the skate to be oval.

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* *Medico-Chirurgical Journal.* 1817.

† *Medico-Chirurgical Transactions.* 1818.

SECT. III.

OF THE SOLIDS IN GENERAL, AND OF THE MUCOUS WEB IN PARTICULAR.

17. THE solids* are derived from the fluids. In the first rudiments of the gelatinous embryo, they gradually commence in their respective situations, and differ infinitely in their degrees† of cohesion, from the soft and almost pulpy medullary matter of the brain, to the vitreous substance of the corona of the teeth.

18. Besides the gelatinous (11) and glutinous (15) parts of the solids, earth enters more or less into their composition, and is principally lime united with phosphoric acid. The bones possess this in the greatest abundance, particularly in advanced age, whereas in childhood the gelatinous matter abounds.

19. With respect to texture, a great part of the solids consist of *fibres* more or less parallel. This may be observed in the bones, especially of fœtuses,‡ in the

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* Hier. Dav. Gaubius, *Spec. exhibens ideam generalem solidarum c. h. partium.* Lugd. Bat. 1725. 4to.

† Abr. Kaau Boerhaave, on the cohesion of the solids in the animal body, *Nov. Comm. Acad. Petropolit.* t. iv. p. 343 sq.

‡ The parallel and reticulated bony fibres are most striking in the radiated margins of the flat bones, as we find these in young heads much enlarged by hydrocephalus. I have, in my museum, a preparation of this kind, where in the sphenoid angles of the parietal bones, the fibres are an inch or two in length, distinct and delicate. The hardest parts,—the bony and vitreous portions of the teeth, exhibit a structure similar to that which in the zeolite, malachite, hematite, &c. all mineralogists call *fibrous.*

muscles, tendons, ligaments, aponeuroses, and in certain membranes, as the dura mater, &c.

20. In other parts no fibres can be discovered, but the texture is peculiar, has been called *parenchyma* from the time of Erasistratus, and differs in different viscera, especially the secreting,---of one kind in the liver, of another in the kidneys.

21. But in all the structures, whether fibrous or parenchymatous, there is interwoven a general *mucous web*,* commonly styled cellular, but improperly, because it rather is continuous, equal, tenacious, ductile, subpellucid, and glutinous.† By handling, it is easily converted into a cellular and vesicular membrane, and demands a place among the most important and remarkable constituents of the body. (A)

22. For, in the first place, many solid parts, v. c. most membranes and cartilages, may by long continued maceration be resolved into it alone. With some it is so intimately united, as to afford a receptacle and support for other constituents: v. c. the hardest bones consisted at first of cartilage, that was originally condensed mucous membrane, but has since become distended by the effusion of bony matter into its substance, which is rendered more lax and cellular. In fact, it is universally present in the solids, if we except the epidermis, nails, hairs, and the vitreous exterior of the corona of the teeth, in which I have never been able to discover it by employing the strongest acid.

23. To the muscles and membranes especially it

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* Dav. Chr. Schobinger, (Præs. Hallero) *De telæ Cellulosæ in fabrica c. h. dignitate.* Gotting. 1748. 4to. Sam. Chr. Lucæ at the end of his *Observ. Anatom. circa nervos arterias adeuntes.* Francof. 1810. 4to.

† Casp. Fr. Wolff, *Nov. Act. Petropol.* t. vi. p. 259.

serves for separation from other parts; to the vessels and nerves for support; and to every part it acts as the common medium of connection.

24. From these facts, two inferences may be drawn. First: That this membrane is so fundamental a constituent of our structure, that, were every other part removed, the body would still retain its form.

Secondly: That it forms a connection between all parts of the system, however different from each other in nature or remote in situation:—a circumstance worthy of attention, as putting an end to the verbal disputes respecting the continuation of membranes, and affording an explanation of many morbid phenomena.

25. As most of the solids owe their existence to this membrane, so again its origin is derived from the lymph of the blood. I have found the lymph changed into this membrane, when transuded on the surface of inflamed lungs, and, by forming false membranes, it afterwards unites these organs to the pleura.

26. We shall now consider some varieties of this membrane. In general, it is more *delicate*, cæteris paribus, in *man* than in animals,—a distinguishing prerogative, by which our sense is rendered more delicate, and our motions and other functions more perfect.* Among different individuals, it varies much in laxity and firmness, according to age, sex, temperament, mode of life, climate, &c.

Finally, it varies in different parts;—more lax in the palpebræ and preputium, and behind the frænum of the tongue; less so around the ears.

* I have treated this point at large in my work, *De Generis Humani varietate nativa.* p. 46. edit. 3.

27. Besides the purposes before mentioned (22,) (23), it is destined for the reception of several kinds of fluids. Its chief use in this respect is to receive that serous halitus which moistens and lubricates every part. This, when formed by the blood vessels, it imbibes like a sponge and delivers over to the lymphatics, thus constituting the grand connection between these two systems of vessels.

28. In certain parts its office is to contain peculiar fluids; v. c. in the eye, existing as the vitreous membrane, it contains the vitreous humour: in the bones, as the medullary membrane (improperly denominated internal periosteum), the marrow; in soft parts, it is in great abundance, and contains the rest of the fat, of which we shall speak hereafter.

NOTE.

(A) Since this structure neither secretes mucus, nor consists of mucus, but chiefly of what becomes gelatine by the operation of boiling water, the generally received appellation of *cellular membrane* appears preferable to that of *mucous tela* adopted by Blumenbach from Bordeu,* and especially in this work, as our author (40) suggests the title of *vis cellulosa* for the contractile power of the membrane.

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* *Récherches sur le tissu Muqueux.*

SECT. IV.

OF THE VITAL POWERS IN GENERAL, AND PARTICULARLY OF CONTRACTILITY.

29. HITHERTO we have spoken of the solids as the constituents of the system; we now shall view them as endowed with *vitality*,---capable of receiving the agency of stimuli, and of performing motions.

30. Although vitality* is one of those subjects which are more easily known than defined, and usually indeed rendered obscure rather than illustrated by an attempt at definition, its effects are sufficiently manifest and ascribable to peculiar *powers* only. The epithet *vital* is given to these powers, because on them so much depend the actions of the whole body during life and of those parts which for a short time after death preserve their vitality, that they are not referrible to any qualities merely physical, chemical, or mechanical.

31. The latter qualities, however, are of great importance in our economy. By physical powers, dependent on the density and figure of the humours of the eye, the rays of light are refracted to the axis; by mechanical, the epiglottis is elastic; by chemical affinity, the changes of respiration are effected. But the perfect difference of these *dead powers* from those which we

* A host of authors on the vital powers will be found in Fr. Hildebrandt's *Lehrbuch der Physiologie*. p. 54 sq. edit. 2. 1809. To whom we may add E. Bartel's *Systemat. Entwurf einer allgemeinen Biologie*. Franckfurt. 1808: and J. B. P. A. Lamarck's *Philosophie Zoologique*. Paris. 1809. 11 vols. 8vo.

are now about to examine, is evident on the slightest comparison of an organised economy with any inorganic body, in which these inanimate powers are equally strong.

32. Indeed the *vital powers* are most conspicuously manifested by their resistance and superiority to the others; v. c. during life, they so strongly oppose the chemical affinities which induce putrefaction, that Stahl and his followers referred their notion of life to this antiseptic property;* they so far exceed the force of gravity, that, according to the celebrated problem of Borelli, a dead muscle would be broken asunder by the very same weight, which, if alive, it could easily raise; &c.

33. As on the one hand, the vital properties are completely different from the properties of dead matter, so, on the other, they must be carefully distinguished from the *mental faculties* which will form the subject of the next chapter: between them, however, there exists an intimate and various relation, observable in many phenomena, but especially in the diversity of temperament.

34. The vital energy is the very basis of physiology, and has therefore been always noticed, though under different *appellations*. The titles of impetum faciens, innate heat, archæus, vital spirit, brute life, head of the nervous system, active thinking principle, vital tonic attraction, have been bestowed upon it by different authors.

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* "Life is formally nothing more than the preservation of the body in mixture, corruptible indeed, but without the occurrence of corruption." STAHL.

"What we call life is opposite to putridity." J. JUNKER.

35. Nor has there been less variety in the *notions* and definitions to which it has given rise; though in this one point all have agreed,—that its nature and causes are most obscure.

36. As to the question so long agitated by physiologists,—whether the diversity of the phenomena exhibited in the similar parts of the living solid is to be attributed to modifications only, or to distinct species, of the vital energy, we think it best to establish *distinct orders of the vital powers*, according to the variety of phenomena by which they are manifested.

37. These phenomena are threefold.—Organic *formation* and increase; *motion* in the parts when formed; *sensation* from the motion of certain similar parts.

38. The first requisite involved in the name and notion of an organised body, is a determinate *form* designed for certain ends. That species, therefore, of the vital powers is most general, which produces the genital and nutritive fluids and prepares them for organic nature. This species we have denominated the *nisus formativus*, since it is the source of all generation, nutrition, and reproduction, in each organised kingdom.

39. Those vital powers which are manifested by *motion*, (37) properly so called, in parts already formed, may be divided into common and proper. The *common* are those belonging to similar parts which are widely distributed: v.c. contractility to the mucous structure; irritability to the muscular fibre. The *proper* are those possessed only by individual organs whose motions are peculiar and characteristic.

40. *Contractility* is as generally distributed as the mucous structure, which it may be said to animate; and therefore would perhaps not improperly be called the

vis cellulosa. It is characterised by a simple and not very sensible effort of the mucous web to contract and react upon its contents, especially upon its source of moisture—the serous vapour, and to propel this into the lymphatic system.*

41. *Irritability,* we mean the irritability of Haller, is peculiar to the muscles, and may be called the *vis muscularis.* It is marked by an oscillatory or tremulous motion, distinguished from the action of simple contractility, by being far more permanent, and by occurring far more easily on the application of any pretty strong stimulus.†

42. Such are the *common* (39) moving vital powers. But some organs differ from the rest so much in their structure, motions, and functions, as not to come under the laws of the common orders of vital powers. We must, consequently, *either* reform the characters of these orders, institute new ones, and extend their limits, *or,* till this be done, separate these peculiar motions from the common orders, and designate them by the name of *vitæ propriæ.*‡ As examples may be adduced, the motions of the iris; the erection of the nipple; the motions of the fimbriæ of the Fallopian tubes; the action of the placenta and of the womb during labour;

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* That Haller and Theoph. de Bordeu—the chief writers on the mucous tela, did not form a just conception of this vital power, is evident from the latter's *Récherches sur le Tissu Muqueux.* Par.1767. 8vo; and from the dissertation of the former on Irritability in the *Dictionnaire Encyclopédique d'Yverdun.* T. xxv.

† Haller, *De Partibus Corp. Hum. irritabilibus* in the *Nov. Comm. Soc. Reg. Scient.* Gotting. T. iv.

‡ I have spoken of these at large both in my treatise *De Iridis Motu.* 1784; and my programma *De Vi Vitali sanguini deneganda.* 1795.

and probably the greater part of the function of secretion.*

43. So much in regard to the vital powers displayed by motion (37, 39, 42). We have now to speak of *sensibility*, which is peculiar to the nervous medulla communicating with the sensorium. It bears the title of *vis nervea*, and is the cause of perception when irritation is excited in parts to which it is distributed.†

44. The *order* which we have followed in enumerating the vital powers, (38, 43) is that in which they successively arise both during our formation and after birth.

The nisus formativus must take place before we can ascertain the existence of the new conception.

Then contractility is exerted in the gelatinous substance of the embryo.

When the muscular fibres are produced, they acquire irritability.

In those few organs whose motions cannot properly be referred either to contractility or irritability, there next exists a vita propria.

Finally, after birth, sensibility is superadded.

45. Similar also is the *order*, according to which the vital powers, both common and proper, are distributed to the *organised* bodies of each kingdom.‡

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* On the vita propria of the absorbent vessels consult Seb. Justin. Brugmans, *De Causa Absorptionis per Vasa Lymphatica.* Lugd. Bat. 1795. 8vo.

On the peculiar vital properties of the arteries consult Chr. Kramp, *Kritik der Praktischen Arzneikunde.* Leipzig. 1795. 8vo.

Many of the phenomena now mentioned are ascribed by others to an orgasm, to use an old expression, struggling from the centre to the circumference, and lately designated vital turgor.

† Fouquet, *Dictionnaire Encyclopédique de Paris.* T. xv. Art. *Sensibilité.*

‡ Consult C. Fr. Kielmeyer, *Uber die Verhältnisse der organischen Kräfte*

The formative power must be most universal; without it indeed organisation cannot be conceived to exist.

Contractility likewise is common to each kingdom.

Irritability and sensibility, in the sense above explained, are peculiar to animals.

Lastly, the *vita propria* is variously observable in some organs, particularly the generative, both of certain animals and vegetables.

46. It is scarcely necessary to remark, that most of these modes of vital energy, though necessarily distinguished into orders, are *intimately* connected; v. c. the mucous web, forming the basis and seat of contractility in so many organs, is interwoven also with the irritable muscular fibres* and the sensible nerves.

47. Whatever may have been the opinions of physiologists respecting the difference or identity of the vital powers, it is universally agreed that they exist in the similar *solid parts*, as the ancients called them, of which the organs or dissimilar parts are composed. But it has been disputed, and particularly of late, whether vitality is peculiar to the solids or common also to the *fluids;* and, the latter being granted, whether or no the *blood* alone is so endowed.

48. As to the *first* question, the whole natural history of each organic kingdom, as far as it has hitherto been cultivated, abundantly shows that those living parts, however delicate, of all known animals and vegetables, are *solid;*—a circumstance necessarily implied in their determinate figure destined for certain uses. For, not

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in der Reihe der verschiedenen Organisationen. 1793. 8vo. H. F. Link, *Uber die Lebenskräfte in naturhistorischer Rücksicht.* Rostock. 1795. 8vo.

* See Abildgaard, *Acta Reg. Soc. Med. Havniens,* T. i.

to speak of entire animals (which, however simple, as worms, are nevertheless supplied with enveloping membranes) the newly laid egg, though at first sight merely fluid, on a more careful examination is discovered to consist of different membranes, of the halones, the cicatricula, &c.

Humidity is indeed necessary in the living solid for the *exertion* of vitality. But that vitality exists in the solid, as solid, is proved by the well-known instances of animalcules and the seeds of plants, in which, although long dried, the vital principle is so entire, that they again live and germinate.

49. With respect to the supposed exclusive vitality of the *blood,* I candidly confess that no fact has been adduced in its favour since the time of Harvey, which might not, I think, be more easily, simply, and naturally explained on the contrary supposition.

For example, the incorruptibility of the blood during life, is far more explicable by the perpetual changes which it undergoes, especially in respiration.

That the blood is the material from which the living solids are produced, is no stronger an argument of its vitality, than the formation of nymphææ and of so many other remarkable plants would be for the vitality of water.

It is difficult to comprehend how the coagulation of the lymph of the blood can demonstrate its vitality. The organic formation of this lymph in generation, nutrition, and reproduction, depends not upon the lymph itself, as lymph, but upon the action of the nisus formativus (38) upon it.

50. Those who formerly contended* that the blood

* v. c. Dan. Bernouilli, *De Respiratione.* Basil. 1721.

"Respiacquires in the lungs from the air a certain principle to be universally distributed during circulation, for the purpose of imparting motion, &c. to the organs, were right, if they regarded that principle (analogous to the *oxygen* of the moderns) as the stimulant of the living solid; wrong, if they regarded it as vitality itself.

51. For it is on all hands agreed, that no motion occurs but upon the action of *stimuli*, to receive which action the vital powers are naturally adapted and intended.

52. These stimuli,* however multifarious, are conveniently reduced to three classes;—*chemical*, *mechanical*, and *mental*. For the present, we shall say nothing of their various modes of action,—in some instances direct,—in others indirect, by sympathy and sensorial reaction. It is sufficient at present to cite a few examples of functions, to which each class of stimuli conspires: such is the increased secretion of tears, saliva, bile, &c. and the venereal turgescence of the genitals.

53. If the nature of stimuli is infinitely various, no less so are their *effects*, according to their nature, intensity, or continued and repeated application to the living solid. Hence they are generally divided into *exciting* and *depressing*.

54. The power of certain stimuli in increasing the

"Respiration supplies a very subtle air, which, when intimately mixed with the blood, greatly condensed, conveyed to the moving fibres, and allowed by the animal spirits to exert its powers, inflates, contracts, and moves the muscles, and thus promotes the circulation of fluids and imparts motion to mobile parts."

* Laur. Bellini, *De Sanguinis Missione.* p. 165—193.
Sylvest. Douglas, *De Stimulis.* Lugd. Bat. 1766.

effects of others, is very remarkable: v. c. the power of caloric, upon which probably national temperament chiefly depends.* That of joy, a most energetic mental stimulus, is similar.† Likewise perhaps that of oxygen, (50) by whose chemical stimulus the vital powers, particularly irritability, are greatly excited, and more disposed to react, upon the impulse of other stimuli.

55. Not less considerable than the variety of stimuli, is that *more minute* discrepancy of the different organs, and of the same organs in different individuals, according to age, sex, temperament, idiosyncrasy, habit, mode of life, &c., to which are owing the diversified effects of the same stimuli upon different organs,‡ and even upon the same in different individuals, and upon which depends what the English have lately termed *specific irritability*.§

56. Lastly, the influence of stimuli by means of *sympathy*, is very extraordinary: by its means, if one part is excited, another, frequently very remote, consents in feeling, motion, or some peculiar function.||

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* Montesquieu, *De l'Esprit des Lois.* T. ii. p. 34. London. 1757. 8vo.

† J. Casp. Hirzel, *De Animi læti et erecti efficacia in corpore sano et ægro.* Lugd. Bat. 1746.

‡ Called *Le Tact ou le Gout particulier de chaque Partie*, by Theoph. de Bordeu, *Recherches Anatomiques sur les Glandes.* p. 376 sq.

§ Sam. Farr, *on Animal Motion.* 1771. 8vo. p. 141.

J. Mudge's *Cure for a recent catarrhous Cough.* Edit. 2. 1779. 8vo. p. 238.

Gilb. Blane, *On Muscular Motion.* 1788. 4to. p. 22.

J. L. Gautier, *De irritabilitatis notione, &c.* Hal. 1793. 8vo. p. 56.

|| J. H. Rahn, *De Causis Physicis Sympathiæ.* Exerc. i.—vii. Tigur. from 1786. 4to.

Sylloge selectiorum opusculor. de mirabili sympathia quæ partes inter diversas c. h. intercedit. Edited by J. C. Tr. Schlegel. Lips. 1787. 8vo.

The primary and most extensive cause of sympathy must be referred to the *nerves*,* and indeed chiefly to the *sensorial reaction*;† so that if one nervous portion is excited, the sensorium is affected, which, reacting by means of the nerves on another part, draws it into consent with the first, although there exist between them no immediate nervous connection. Such is the sympathy of the iris, when the retina is stimulated by light; and of the diaphragm during sneezing, when the Schneiderian membrane is irritated.

There are other examples of sympathy, in which the nerves, if they have any, have a more remote and accessory, share:‡ among these must be placed the sympathy along the *blood vessels*, strikingly instanced between the internal mammary and epigastric arteries, especially in advanced pregnancy; that along the *lymphatic vessels*,§ also most remarkable during pregnancy and suckling; and again, that dependent on *analogy of structure and function*, v. c. the sympathy of the lungs with the surface and intestines. (A)

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* G. Egger (the author Lawr. Gasser), *De consensu nervorum*. Vindob. 1766. 8vo.

† J. G. Zinn's Observations on the different Structure of the Human Eye and that of Brutes. Diss. ii. 1757. *Comment. Soc. Reg. Scient. Gotting. antiquiores*. T. i.

‡ Consider the constant sympathy of heat between certain parts of some animals, v. c. of the hairs with the fauces, in variegated rabbits, sheep, dogs, &c.; of the feathers with the covering of the bill and feet in varieties of the domestic duck. That many such instances are not referrible to the influence of nerves, I contended in my *Comm. de motu iridis*. p. 12 sq. and also in my work *de generis humani varietate nativa*. p. 364 sq.

§ Innumerable pathological phenomena will be found explained by this sympathy in S. Th. Soemmerring's *De Morbis Vasorum Absorbentium Diss. quæ præmium retulit*. Francof. 1795. 8vo.

57. The vital powers will be hereafter separately considered, under the distinct heads of our subject:—The nisus formativus under the head of Generation; irritability under that of the Muscles; sensibility under that of the Nervous System; the *vita propria* whenever occasion requires.

58. Besides our former brief remarks (40) upon *contractility,* a few more minute will at present be very appropriate.

It prevails universally,(40) wherever the mucous tela is discoverable.

It is consequently most abundant in parts destitute of proper parenchyma, but composed almost entirely of mucous tela, v.c. in certain membranes: for no one will deny their contractility, who reflects upon the spastic motions of the dartos, the male urethra, or the gall bladder, which during death is always closely contracted upon any calculi it may contain.

It appears also in those viscera which consist chiefly of this tela, v. c. in the lungs, whose external surface we have found on living dissection very contractile; but by no means, as Varnier asserted, truly irritable. (B)

The presence of contractility even in the bones, is demonstrated by the shrinking of the alveoli after the loss of the teeth, and by the process of necrosis, by which the new bone, when the dead portion is extricated from its cavity, contracts to its natural size and figure.

The vitreous substance of the teeth, being destitute of this tela (22), possesses no contractility, as I think appears from the circumstance of its not shrinking, like the alveoli, if a portion is separated by caries or fracture.

59. This contractility of the mucous tela is the chief

cause of strength, health, and beauty; since on it depend the vital elasticity and fulness,* and indeed the *tone* of parts, so elegantly decribed by Stahl; for by its means, the mucous tela, to mention one only of its functions, absorbs, during health, the serous fluid (27) like a sponge, and propels it into the lymphatic vessels: in disease, on the contrary, having lost its tone, it is filled with water, giving rise to œdema and similar cachexies.

60. Finally, the great influence of this contractility in producing the peculiar constitution and temperaments of individuals, is manifest from its universal existence, its close union with the other vital powers, and from its infinite varieties and degrees in different persons.

NOTES.

(A) John Hunter divides sympathy into general and partial; such as fever from a wound, and convulsion of the diaphragm from irritation in the nose. Partial sympathy he subdivides into remote, contiguous, and continuous,—Where there is no evident connection between the sympathising parts, sufficient to account for the circumstance,—Where there is proximity of the sympathising parts,—and Where, as most commonly, the sympathising parts are continuous.†

Bichat's division is much better.‡ It cannot be understood, indeed, till after the perusal of the note to the sixth section.

* Hence after death, even in young subjects full of juices, the back, loins, and buttocks, having for some time lost their vital tone, are, if the body is supine, depressed and flattened by the superincumbent weight, which now is not resisted: this appearance I regard among the indubitable signs of death.

† *Treatise on the Blood, &c.* Introduction.

‡ *Anatomie Générale.* T. i. p. 183 sq.

He considers sympathy as affecting either animal sensibility or contractility, or organic sensibility or contractility.

Sympathy does not arise from nervous communication, because it frequently happens that no particular nervous communications of sympathising parts are discoverable, while remarkable ones exist between other parts not disposed to sympathise.* Vegetables, which have no nerves, shew sympathy:—if a leaflet of the sensitive plant is stimulated by a burning glass, the whole leaf contracts and the foot-stalk drops; † when the branches of trees feel the warmth of summer, the sap ascends in the roots; and even in a frost it will ascend from the roots through the stem, if a single branch is introduced into a hot-house.

Sympathy of animal contractility occurs only when the nerves connecting the affected muscles with the brain, are entire; when they were divided by Bichat, the convulsions in the corresponding muscles ceased. The sympathies of the organic functions are never ascribable, as many might imagine, to continuity of surface; for after dividing the œsophagus of a dog, Bichat produced vomiting equally as before, on irritating the fauces.

(B) Our author here, as below (135), means the pulmonary portion of the pleura, and very properly regards this and other serous membranes, as condensed cellular substance; that is, as a substance not originally cellular and now condensed, but of the same nature with the cellular membrane, though much more compact. ‡

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* Consult Whytt, *Observations on Nervous Diseases.* Ch. i.

† Sir Gilbert Blane, *Medical Logic.* p. 61.

‡ Consult Bichat, *Traité des membranes.*

SECT. V.

OF THE MENTAL FACULTIES.

61. MAN, whom we have found possessed of a body, answering completely both in matter and texture, as well as vital powers, the purposes of its formation, is endowed likewise with a *mind*, a "divinæ particula auræ," intimately connected with the body, and developing by education and exercise various kinds of faculties, which we shall concisely enumerate, as far as they belong to our subject.*

62. The sensibility of the nerves, mentioned above among the vital powers, (43) constitutes, as it were, the medium which propagates the impressions of stimuli upon sensible parts, and especially upon the organs of sense (to be hereafter examined), to the sensorial portion of the brain, in such a manner that they are perceived by the mind.

63. The mental faculty to be first enumerated, and indeed to be placed at the bottom of the scale, is the faculty of *perception*, by means of which the mind takes cognizance of impressions made upon the body, and chiefly upon the organs of sense, and becomes furnished with ideas.

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* Consult Alex. Chrichton, *Inquiry into the nature and origin of mental derangement, comprehending a concise system of the Physiology and Pathology of the human mind.* Lond. 1798. 2 vols. 8vo. Em. Kant, *Anthropologie in pragmatischer Hinsicht.* Königsb. 1798. 8vo. Chr. Meiner, *Untersuchungen über die Denkkräfte und Willenskräfte des Menschen nach Anleitung der Erfahrung.* Gött. 1806. 2 vols. 8vo.

64. This faculty is assisted by another of an higher order,—*attention*, which so directs the mind, when excited, to any idea, that it dwells upon that idea alone and surveys it fully.

65. To preserve and recall the marks of ideas, is the office of *memory*—that part of the mind, which, in the language of Cicero, is the guardian of the rest.

66. *Imagination*,* on the contrary, is that faculty of the mind, which represents not merely the signs, but the very images, of objects in the most lively manner, as if they were present before the eyes.

67. *Abstraction* forms general notions more remote from sense.

68. *Judgment* compares and examines the relations of the ideas of sense and of abstract notions.

69. Lastly *reason*—the most noble and excellent of all the faculties, draws inferences from the comparisons of the judgment.†

70. The combination of these constitutes the *intellectual faculty*; but there is another order, relating to *appetency*, the word being taken in its most extensive meaning.

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* The difference, analogy, and relation, of memory and judgment, have given rise to various controversies. Some celebrated psychologists have included both under the word *imagination* taken in its most comprehensive sense, and have divided it into two species; *memory*—representing former ideas, and the *facultas fingendi*—representing such ideas only as are formed by abstraction. They again divide memory into *sensitive* (imagination in a stricter sense) and *intellectual*.

Their *facultas fingendi* they also subdivide into *intellectual*—the more excellent; and *phantasy*—obeying mechanical laws. Feder, *Grundsätze der Logik und Metaphysik*. Götting. 1794. p. 20.

† Of this the highest prerogative of the human mind, by which man exerts his dominion over other animals, and indeed over the whole creation, I have fully treated in my book *De Gen. Hum. Var. Nat.* p. 32. ed. 3.

71. For since we are impelled by various internal stimuli to provide food and other necessaries, and also to satisfy the sexual instinct, and are impelled the more violently, in proportion as imagination inflames our wishes, *desires*, properly so called, are thus produced; and if, on the other hand, the mind becomes weary of unpleasant sensations, *aversions* occur.

72. Finally, that faculty which selects out of many desires and aversions, and can at pleasure determine to perform functions for certain purposes, is denominated *volition*.

73. Our order of enumeration corresponds with that of the development of the faculties, and with the relation in which those termed brute—common to man and animals, and those more or less peculiar to man, stand to each other.

NOTE.

Dr. Gall gives a very different view of the mental faculties. Instead of dividing them into memory, judgment, &c. as fundamental faculties; and viewing "the Power of Taste, a genius for Poetry, for Painting, for Music, for Mathematics," &c. as "more complicated powers or capacities, which are gradually formed by particular habits of study or of business;" * he regards these last powers as distinct faculties, and memory, judgment, &c. merely as modes or varieties common to the action of each faculty. He contends that when we see a boy, brought up exactly like his brothers and sisters, displaying fine musical talents or an asto-

* Dugald Stewart, *Outlines of Moral Philosophy*. p. 10.

nishing power of calculation, though in all other respects a child, his pre-eminence cannot be explained by particular habits of study or of business, nor by mere strength of judgment.

For my own part when I reflect upon the various talents and dispositions of persons all in the same circumstances—how unsuccessfully some apply, with the utmost perseverance, to a branch of study, in which another under the same instructors, or perhaps scarcely assisted at all, reaches excellence, with little trouble—how early various tempers are developed among children of the same nursery—how hereditary peculiarities of talent and character are—how similar some persons are to each other in one respect, and dissimilar in another—how positively contradictory many points of the same character are found; I confess myself unable to deny that there is one innate faculty for numbers, another for colours, a third for music, &c. &c. with a variety of distinct innate sentiments and propensities; and that memory, judgment, &c. are but modes of action common to the different faculties and partly to different sentiments and propensities.

The sentiments and propensities which Dr. Spurzheim enumerates, respect sexual love, love of offspring, inhabiting particular situations, attachment, contention, destruction, construction, acquirement, concealment, love of self, love of praise, cautiousness, benevolence, veneration, hope, conscientiousness, decision,* and imitation.† The particular intellectual faculties, according to the same author, are for judging of form, size, weight, colour, space, number, tune, order? time? He enumerates likewise a faculty relating to languages, one to the ludicrous, one to poetry, one to judging of cause and effect, one to the cognisance

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* I was convinced of this being a distinct power, upon perusing an Essay on decision of character, written some years ago by a dissenting minister who I dare say never thought of craniology. *Essays* by John Foster.

† A wonderful *instance* of this propensity is detailed in the *Philos. Trans.* 1677. The strength of it seems part of the *national* character of the Ashantees. Bowditch, *Mission from Cape Coast Castle to Ashantee.* p. 292.

of the ideas of all the other faculties, and one again to their comparison.

I should be extremely sorry to affirm that this is a complete or accurate account of the faculties, sentiments, and propensities of the human mind, or that Dr. Spurzheim's book * contains no bad reasoning nor ridiculous illustration; but I am convinced that Dr. Gall has given us the first correct sketch of the constituents of the human mind, whatever more labour may be necessary to complete the detail, and has put us in the only right road for learning all that can be known of it. (218. E)

Every sentiment and propensity was given us for a good purpose, and it is only when one is naturally or by indulgence excessive, thwarting and crossing the operation of others, and especially of conscientiousness, that error occurs; and on this subject the profound metaphysical sermons, preached at the Rolls Chapel by the pious and exemplary Bishop Butler, highly deserve perusal. † The natural tendency of our faculties, the Bishop proves, is to virtue. Their mutual thwartings occasion the deformities of the moral world, exactly as the crossing of physical laws gives rise to the blemishes of inanimate nature. Nor do I believe that the beauties of the inanimate world surpass the beauties of the moral, or that the deformities of the moral are more appalling than the deformities of the physical. Both are governed by wise general laws; good is the object, evil the occasional, incidental, accompaniment. (666. E)

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* *The Physiognomical System of Drs. Gall and Spurzheim.*

† *Serm.* i. Upon the social nature of man. *Serm.* ii. iii. Upon the natural supremacy of conscience.

SECT. VI.

OF HEALTH AND HUMAN NATURE.

74. Since *health*,* which is the object of physiology, depends upon such an harmony and equilibrium of the matter and powers of the system, as is requisite for the due performance of its functions, it is very evident how the four principles, examined above, contribute to its support.

75. *Fluids* properly prepared are the first requisite; in the next place, *solids* duly formed from the fluids; then the invigorating influence of the *vital powers*; lastly, a sound *mind* in this sound body.

76. These four principles *act* and *react* perpetually upon each other: the fluids are stimuli to the solids; these again are calculated by their vital powers to experience the influence of these stimuli, and react upon them. In reference to the intimate union of the mind with the body, suffice it at present to remark, that it is far more extensive than might at first be imagined. For instance, the influence of the will is not confined within the narrow limits of those actions designated voluntary in the schools of physiology; and the mind, on the other hand, is influenced by the affections of the body, in many other ways than by the perceptions of sense.†

* Theod. G. Aug. Roose, *Uber die Krankheiten der Gesunden.* Götting. 1801. 8vo.

G. Chr. Klett, *Tentamen evolvendi notionem de sanitate hominis.* Wirceb. 1794. 8vo.

† Galen, *quod animi mores corporis temperaturas sequantur.*

77. From the endless variety and modification of the conditions belonging to these four principles, it may be easily understood what great *latitude** must be given to the notion of health. For since, as Celsus long ago observed, every one has some part weaker than the rest, Galen may in this sense assert with truth, that no one enjoys perfect health. And even among those whom we commonly regard as in good health, this is variously modified in each individual.†

78. Upon this endless modification is founded the difference‡ of *temperaments;* or, in other words, of the mode and aptitude of the living solid§ in each individual, to be affected by stimuli, especially the mental; and again, of the mental stimuli, to be excited with greater or less facility.

79 So various are the differences of degree and combination in the temperaments, that their *divisions* and orders may be multiplied almost without end. We

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St. J. Van. Geuns, *De corporum habitudine animæ hujusque virium indice ac moderatrice.* Harderv. 1789. 4to.

* Galen, *De sanitate tuenda.* L. i.

† W. F. Ad. Gerresheim, *De sanitate cuivis homini propria.* Lugd. Bat. 1764. 4to.

‡ Lavater, *Physiognomische Fragmente.* T. iv. p. 343.

W. Ant. Ficker, *Comm. de temperamentis hominum quatenus ex fabrica et structura corporis pendent.* Gotting. 1791. 4to.

J. N. Hallé, *Mem. de la Soc. Médicale d'Emulat.* T. iii. p. 342.

§ To the numerous arguments by which the moderns have overthrown the doctrine of the ancients, and proved that the temperament depends on the living solids rather than on the nature of the blood, I may add the celebrated example of the Hungarian sister twins, who, at the beginning of the last century, were born united at the lower part of the back, and attained their twenty-second year in this state. They were, as is well known, of very different temperaments, although dissection discovered that their sanguiferous systems anastomosed so considerably that the blood of both must have been the same.

shall content ourselves with the four orders commonly received.* The *sanguineous*—excited most readily, but slightly: The *choleric*—excited readily and violently: The *melancholic*—excited slowly, but more permanently: And the *phlegmatic*—excited with difficulty.

This division, although built by Galen upon an absurd foundation borrowed from an imaginary depravation of the elements of the blood, appears, if made to stand alone, both natural and intelligible.

80. The predisposing and occasional *causes* of the diversity of temperaments are very numerous; v. c. hereditary tendency, habit of body, climate, diet, religion, mode of life, and luxury.†

81. Besides the variety of temperaments, circumstances peculiar to every individual, by influencing the *number*, as well as the *energy* and *vigour*, of the *functions*, increase the latitude (77) in which the term health must be received. In regard to age, the health of a new-born infant is different from that of an adult; in regard to sex, it differs in a marriageable virgin and an old woman past child-bearing, and during menstruation and suckling; in regard to mode of life, it is different in the barbarous tribes of North America and in effeminate Sybarites.

Moreover, in every person, custom has an extraordinary influence‡ over certain functions, v. c. sleep,

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* Kant, l. c. p. 257 sq.

† Feder, *Untersuchung über den menschlichen Willen.* T. ii. p. 49.

‡ Galen, *De Consuetudine.*

G. E. Stahl, *De consuetudinis efficacia generali in actibus vitalibus.* Hal. 1700. 4to.

H. Cullen, *De Consuetudine.* Edinb. 1780. 8vo.

C. Natorp, *De vi consuetudinis.* Gott. 1808. 4to.

diet; and has therefore acquired the name of second nature.

82. The more functions flourish simultaneously in the body, the more considerable is its *life;* and *vice versâ.* Hence life is greatest when the functions have attained their highest perfection in adult age; and least when the functions, although very perfect, are fewer and more sluggish, v. c. in the newly conceived embryo; life is for the same reason less vigorous during sleep than during the opposite state.

83. The functions have been long divided by physiologists into four classes. This division, although not unexceptionable nor exactly conformable to nature,* may assist the memory.†

1. The first class comprehends the *vital* functions, so termed, because their uninterrupted and complete performance is necessary to life. Such are the circulation and respiration.

2. The second comprehends the *animal* functions, by which animals are chiefly distinguished from vegetables. Such is the connection of the mind with the body, especially sense and muscular motion.

3. The third is the *natural,* by means of which the body is nourished.

4. The fourth, the *genital,* intended for the propagation of the species.

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* See Platner, *Quæst. physiol.* p. 31; and *Versuch einer Anthropologie.* T. i. p. 100, 222; and my own remarks on the bad foundation of this division, in the preface to my *Enchiridion Anat. Comparatæ,* p. xi sq.

† J. J. Bernhard, *Versuch einer Vertheidigung der alten Eintheilung der Functionen, und einer Classification des organisirten Körper nach denselben.* Erf. 1804. 8vo.

We shall now examine each of these separately, beginning with the vital.

NOTE.

The consideration of a division as ancient as Aristotle, and preferable to that which Blumenbach adopts, will perhaps form an useful note to the eighty-third paragraph and the greater part of the fourth section.

In this, the functions are arranged in two classes:—the animal constituting one peculiar to animals; and the vital and natural united into another, common to vegetables and animals, under the title of organic or vital. The generative, relating in their object to the species rather than to the individual, and of but temporary duration, are thrown into a separate and inferior division, but in fact are merely part of the organic.

We owe the revival of this classification, and our knowledge of the characteristics of each class of functions, to Dr. Wilson Philip * and Xavier Bichat, † although the latter, from having published a work expressly on the subject, has received the whole honour, both in great Britain and on the Continent.

The *animal* functions prove us feeling, thinking, and willing beings: they are the actions of the senses which receive impressions, of the brain which perceives them, reflects upon them, and wills; of the voluntary muscles which execute the will in regard to motion; and of the nerves which are the agents of transmission. The brain is their central organ. The *vital* or

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* *Treatise on Febrile Diseases.* Ch. iii. Sect. 3. First Edition. 1799. *Paper read to the Royal Med. Society of Edinburgh.* 1791 *or* 1792, *and inserted in its Records. Essay on Opium.* 1795. *Edinburgh Med. and Surgical Journal.* July. 1809. p. 301 sq.

† *Récherches Physiologiques sur la Vie et la Mort.*

organic functions are independent of mind, and give us simply the notion of life: they are digestion, circulation, respiration, exhalation, absorption, secretion, nutrition, calorification. The heart is their central organ.

The organs of the animal functions are double and correspondent, there being on each side of the median line of the body, either two distinct organs, as the eyes, ears, extremities; or two correspondent halves, as is the case with the brain, spinal marrow, nose, tongue, &c.

The organs of the vital or organic functions, are in very few instances double or situated with their centres in the median line and possessed of symmetrical halves; witness the heart, stomach, liver. There are indeed two kidneys, but they continually differ in size, figure, and situation: the two lungs are very dissimilar.

Hence Bichat infers, that in the animal functions a harmony of action in each organ or each half of the organ, is indispensable to perfection, when both organs or sides act together; and that if such harmony do not occur, it would be better for one organ or one half to act alone. This is unquestionably true of the eye, but can be supposed by analogy only with regard to the brain, ears, &c. It certainly does not hold good in the actions of the voluntary muscles, nor in the operations of the brain or spinal marrow in willing those actions. From the duplicity of the organs it also happens that one side may cease to act without detriment to the function of the other; while in the vital or organic class no harmony of action is possible and the derangement of any one part of an organ generally affects the whole of it,—an obstruction in the colon disturbs the functions of all the alimentary canal.

The animal functions experience periodical intermissions—sleep. The organic or vital continue incessantly, suffering merely remissions:—the blood constantly circulates, the perspiratory fluid is constantly secreted, the stomach has no sooner digested one meal than we commit another to it; yet we shall hereafter see that the actions of the heart, lungs, &c. have daily intervals of remission.

The animal functions are much influenced by habit; the vital or organic are considered by Bichat as removed from its influence. The power of habit over our sensations and voluntary motions is manifest: yet I think it equally great over the organic functions. The operation of food and of all descriptions of ingesta is most remarkably modified by habit; through it poisons become comparatively innoxious, and divers bear a long suspension of respiration.

Bichat regards the passions as directly influencing the organic functions only, and springing from the state of the organs of that class. Here he is to me perfectly unintelligible. Vexation indeed disturbs the stomach, and fear augments the quantity of urine; but does not vexation equally and as directly disturb the mind—confuse the understanding, and occasion heat and pain of the forehead? Are not, in fact, the passions a part of the mind?—a part of the animal functions? They powerfully affect, it is true, the organic or vital functions, but this shows the close connection merely between the two classes of functions.

This connection is conspicuous in respiration, the mechanical part of which belongs to the animal functions, the other to the organic; and in the alimentary actions, in which the food is swallowed and the fæces rejected by volition, and digestion, &c. performed, independently of our influence, by the powers of simple life. So close indeed is this connection, that every organ of the animal class is the seat of organic functions;—in the voluntary muscles, the organs of sense, and even in the brain, circulation, secretion, and absorption are constantly carried on. This connection is likewise apparent in the property of sensibility. In the language of Bichat there are *animal sensibility and contractility*, and *organic sensibility and contractility*, besides the common extensibility of matter, which he terms *extensibilité de tissu*, and common contractility upon the removal of distention,—*Contractilité par défaut d'extension*, confounded by Blumenbach

(58. clause 5 and 6) with purely vital contractility, and indeed greater during life than afterwards.* *Animal sensibility* is accom-

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* The following is Bichat's table of the properties of the living body:—

	Classes.	*Genera.*	*Species.*	*Varieties.*	
Properties.	1 Vital	1 Sensibility	1 Animal		
			2 Organic		
		2 Contractility	1 Animal		
			2 Organic	1 Sensible.	Such as the motion of the heart and *alimentary* canal.
				2 Insensible.	Such as the motion of the *capillaries.*
	2 Structural	1 Extensibility			
		2 Contractility			

Although these are the general properties of the living frame, and sensibility, or more properly excitability, is at the bottom of all other vital or organic properties except the active power of contraction, yet each part has also some peculiarity, altogether inexplicable, not in the least, I think, to be accounted for on Bichat's supposition of each part possessing a certain *degree* of organic sensibility in relation to its fluids. What causes the vessels of muscle to produce muscle; of bone, bone; of membrane, membrane; what causes the secreting vessels of the liver to form bile, and of the testes semen, we know not. The cause of these circumstances may be called by Blumenbach, after Bordeu, *vitæ propriæ;* but it must be carefully remembered that this expression simply denotes an unknown cause of a fact, and affords no explanation.

Feeling, I use the word for want of another to embrace consciousness and perception, is in the same manner at the bottom of all the mental properties except the active power of willing, but it alone will not explain them. All matter is probably the same; but its *modifications* also are so various that at present we are compelled to speak of distinct kinds of matter.

The operation of agents on the system is analogous. As far as they all affect the living solid they may be all called stimuli; but they differ in something more than *degree* of stimulus. Each affects in a peculiar way; some directly depress life, and many occasion opposite results in different parts.

When organic sensibility is heightened in one part, it sinks in another, and vice versâ, unless the change of it should be such as to extend generally, and even then it is still frequently found in the opposite state in some particular part:—we notice coldness of the feet and fulness of the head together; blisters relieve internal inflammation, and irritate the more difficultly in proportion to the violence of the internal disease. The same phenomena are observable in animal sensibility and in the mind at large:—

panied by a perception in the mind, as in seeing, hearing, tasting, smelling, feeling: *animal contractility* is excited by the volition of the mind conveyed to the voluntary muscles by means of the nerves. *Organic sensibility* is attended by no perception, and is followed by contraction totally independent of the will:—the heart feels, if we may so speak, (physiology has no proper term for the idea) the stimulus of the blood, and, without our influence, forthwith contracts; the lacteals feel the stimulus of the chyle without our knowledge, and propel it without our assistance. But although we never acquire the least direct voluntary power over the actions of organic contractility,—over the peristaltic motion of the intestines or the contractions of the blood vessels,

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"Tut, man! one fire puts out another's burning,
"One pain is lessen'd by another's anguish;
"Turn giddy, and be holp by backward turning;
"One desperate grief cures with another's languish;
"Take thou some new infection to thy eye,
"And the rank poison of the old will die."

SHAKSPEARE. *Romeo, Act.* i. *Sc.* ii.

The effect of vicissitudes of temperature, and a large number of other pathological phenomena, are principally explicable on the derangement of the balance of excitability and for the most part *consequently* of circulation. (Sect. XX. B)

Notwithstanding it is a general law (53) that the effects of a stimulus diminish the more frequently it is applied, yet if it is applied so energetically as to leave the sensibility heightened, especially if to the point of inflammation, its subsequent power is greatly increased. Immense potations of spirituous liquors may gradually be borne, but if the increase is too sudden, the sensibility of the stomach may become such that a single glass will prove violently irritating.

The specific action of one agent frequently prevents that of another;—small-pox and measles very rarely occur together, and the former is often prevented for ever by the cow-pock.

While moderate excitement is necessary to maintain action, violent wears out the power, and very violent may suddenly destroy life altogether: according to the verses,

Nutritur ventis, ventis extinguitur ignis,
Lenis alit flammas, grandior aura necat.

yet every organ of the organic functions may have its organic sensibility heightened into animal sensibility, as inflammation, for instance of the pleura and the joints, daily demonstrates: indeed, in some organs of that class of functions, we invariably have sensation;—the stomach is the seat of hunger, in the lungs we experience an uneasy sensation nearly as soon as their air is expelled.

The nerves of the animal functions run to the brain or spinal marrow; those of the organic chiefly to ganglia; but, as might be expected, the two nervous systems have abundant communications.

The animal functions have not only a shorter existence than the organic from their necessity of alternate repose, but they flourish for a shorter duration,—they do not commence till birth, they decline, and, in the natural course of events, terminate, earlier,—the organs of sense and the mental faculties fail before the action of the heart and capillaries. The decay of the animal functions must, in truth, be the consequence of the decay of the organic, because there are fundamentally in every part organic functions,—circulation, nutrition, &c. and the perfect performance of these in the organs of the animal functions is indispensable to the perfect performance of the animal functions. Hence the impairment of these organic functions, even to a small extent, must derange or diminish the animal functions, which will thus decline while there is still sufficient life for the organic functions to continue.

We thus find in every living system a class of functions, not in themselves dependent upon mind, as perfect in the vegetable as in the animal, and pervading every part of the system. In animals there further exist certain parts which when endowed with the common life of other parts,—with the organic properties, are able to perform peculiar functions which give us the notion of mind: the organ of these functions is termed brain, and, by means of nerves and medullary prolongations, it maintains a correspondence with the whole machine, influenced by and influencing the most distant parts. The phenomena of the mind have been metaphysically considered in the fifth section; they will be examined as functions of the nervous system in the twelfth.

The ORGANIC FUNCTIONS depend on life in the proper acceptation of the word. The word life should be regarded, like the word attraction or repulsion, as merely an expression of a fact. In this point of view it may be as easily defined as any other expression. By life we generally mean the power of organised matter to preserve its particles in such chemical relations as to prevent other chemical relations from inducing disorganisation, or even to increase or decrease by internal appropriation and separation; to preserve in some measure a temperature distinct from that of the surrounding medium; to move certain parts of itself sensibly (as muscles) or insensibly (as the capillaries) independently of mere impulse, attraction, or repulsion: or if not organised (as the fluids which form the embryo, the blood,) the power of matter produced by an organised body endowed with the properties above mentioned, to resist the ordinary chemical influences, and directly form (as the genital fluids) an organised system so endowed, or directly contribute (as the blood) to the organised substance of an already formed system so endowed.

That fluids are as susceptible of life as solids I cannot doubt. There is no reason why they should not be so, although a person who has not thought upon the subject may be as unable to conceive the circumstance as a West Indian to conceive that water may by cold become solid. It is impossible to deny that the male and female genital fluids are alive, because from their union a living being is produced that partakes of the vital qualities of each parent. Accordingly Blumenbach, in his *Commentatio de vitali sanguinis,* * grants both male and female genital fluids to be alive,

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* "In universum sane post omnia quæ super hoc argumento sive meditando sive experiundo hactenus elicere licuit, nulli humorum nostri corporis genuina

nothwithstanding that he fancies his victory over the defenders of the blood's life so complete, that like that of the unfortunate Carthaginian Dido, as he says, "*in ventos vita recessit.*" It is as easy to conceive the blood to be alive as the genital fluids. The great asserter of the life of the blood is Mr. Hunter,* and the mere adoption of this *view of the facts* relative to that fluid by Mr. Hunter, would entitle it to the utmost respect from me who find the most ardent and independent love of truth, and the genuine stamp of genius, in every passage of his works. The freedom of the blood from putrefaction while circulating, and its inability to coagulate after death from arsenic, electricity, and lightning, may, like its inability to coagulate when mixed with bile, be simply chemical phenomena, independent of vitality. But its inability to coagulate after death from violent exercise, anger, or a blow on the stomach, which deprive the muscles likewise of their usual stiffness; its accelerated coagulation by means of heat; perhaps its diminished coagulation by the admixture of opium; its earlier putridity when drawn from old than from young persons; its freezing, like eggs, frogs, snails, &c. more readily when once previously frozen (which change may be supposed to have exhausted its powers); its directly becoming

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vis vitalis tribuenda videtur, si unice a genitali utriusque sexus latice discesseris, utpote cui jam arte quam uterino cavo exceptus et intime mixtus in fœtus formationem abit, vitales inhærere vires formativas, præter alia paterni vultus in nepotes propagata similitudo, aliaque id genus phænomena haud infitianda demonstrare videntur." *Comment. Soc. Reg. Societ. Gotting.* vol. ix. p. 12.

* The doctrine of the life of the blood was maintained by Harvey (Exercit. L. *De Generationis ordine*, &c.) Glisson (*De ventriculo et intestinis*) and Albinus. (Blumenbach's *Commentat.* l. c.) I am surprised that Moses should be adduced as authority for this opinion. When he says (*Leviticus.* ch. xvii. 11, 14.) "For the life of the flesh is in the blood"—"For it is the life of all flesh," he can mean only that when it is withdrawn, life ceases,—that it is necessary to the life of animals. He also says (v. 14.) "the blood of it is FOR the life thereof." The construction which would make Moses assert that the blood is alive, involves the absurd assertion that the blood only is alive.

the solid organised substance of our bodies, while the food requires various intermediate changes before it is capable of affording nutriment; the inosculation of the vessels formed in extravasated blood and secreted lymph with those of surrounding parts; and finally the production of the genital fluids from the blood itself; do appear to me very strong arguments in favour of the life of the blood.* I am inclined with Mr. Hunter to believe that the chyle is alive, and that vivification commences even in the stomach, although I should be sorry to go the same length with Albinus, who granted life even to the excrement. For the excretions must be regarded as dead matter, useless and foreign to the system; and they all run with the greatest rapidity into decomposition. In operating for retention of urine, the surgeon finds this fluid abominably fœtid; the fæces become so when not discharged in due time; and the neglect of washing the surface is the source of filthiness and disease.

The essential nature of life is an impenetrable mystery, and no more a subject for philosophical inquiry than the essential nature of attraction or of matter. To attempt explaining the phenomena of life by a vital fluid is only increasing the intricacy of the subject by an unfounded *hypothesis*, and always reminds me of Mr. Dugald Stewart's remark,—that "There is even some reason for doubting, from the crude speculations on medical and chemical subjects which are daily offered to the public, whether it (the proper mode of studying nature) be yet understood so completely as is commonly imagined, and whether a fuller illustration of the rules of philosophising, than Bacon or his followers have given, might not be useful even to physical inquirers."† We see matter in a certain state possessed of a certain power which we term life, and the object of physiology is merely to observe its effects, just as it is the object of chemistry to observe the circumstances of the affinity of different bodies and

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* Consult Hunter's *Treatise on the Blood*, &c. P. i. ch. i.

† *Elements of the Philosophy of the Human Mind.* Vol. i. p. 8.

of physics to observe other phenomena of matter, without vainly speculating on the essence of affinity or the essence of matter, to comprehend which our faculties are in their nature incompetent. By attributing life, the power of attraction, &c. to subtle and mobile fluids, we not only do not advance a single step, for we have still to explain what these fluids are and how *they* obtain *their* powers, just as we had before in regard to common matter, but we make the additional mysteries of their being united with ordinary matter, and so united that life appears a power possessed by it. The editors of a medical review have in vain searched Mr. Hunter's works for such an *hypothesis,** and Mr. Lawrence has had no better success,† so that I apprehend his meaning has been misunderstood by those who constitute him its patron. ‡ Granting for a moment that life depends on a peculiar fine fluid, we have still to account for *mind,* because life is not mind,—a cabbage is as much gifted with life as the wisest man.

We have reason to believe that life never originates, but was granted at the creation, and is communicated to assimilated matter and propagated from parent to offspring (622. B.) ; it is the property of organised systems, producing various effects by various kinds of organisation, but not quite peculiar to organised matter, because capable of being possessed by matter in a fluid state. §

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* *Annals of Medicine and Surgery.* 1817. p. 373. In the *Treatise on the Blood,* (p. 89 sq.) Mr. Hunter says "Life is a *property* (not a subtle fluid) we do not understand." This property he conceives to reside in a certain matter similar to the materials of the brain; diffused through the body and even contained in the blood. "The brain," he adds, "is a mass of this matter, not diffused through any thing, for the purpose of that thing, but constituting *an organ* in itself." This *materia vitæ* is therefore pretty solid and no other than medullary matter. Its diffusion through the body will not bear mentioning in the present day.

† *Lectures on the Physiology, Zoology, and Natural History of Man.* p. 84.

‡ J. Abernethy, *Lectures delivered before the Royal College of Surgeons.* 1814.

§ As the fluids which form the embryo must be endowed with life, organisation cannot be the cause of life; but in truth organisation is the effect of

The ANIMAL FUNCTIONS demonstrate mind. This is seated in the brain, to which the spinal marrow, nerves, and voluntary muscles are subservient. Mind is the functional power of the living brain. As I cannot conceive *life* any more than the power of attraction unless possessed by matter, so I cannot conceive *mind* unless possessed by a brain endowed with life. (666. F). I speak of terrestrial or animal mind; with angelic and divine nature we have nothing to do, and of them we know, in the same respects, nothing. To call the human mind positively a ray of the divinity, (*Divinæ particula auræ,* Ex ipso Deo decerptus, Ex universa mente delibatus*†) appears to me absolute nonsense. Brutes are as really endowed with mind,—with a consciousness of personality, with feelings, desire, and will, as man. Every child is conscious that it thinks with its head, and common language designates this part as the seat of mind.‡ Observation shows that superiority of mind in the animal creation is exactly commensurate with superiority of brain (666. F); that activity of mind and of brain are coequal; and that as long as the brain is endowed with life and remains uninjured, it, like all other

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life, although when produced it becomes an instrument of life. The erroneousness of the French doctrine to which Mr. Lawrence is a proselyte (*Two Introductory Lectures*, &c.),—that "life is the result of organisation," was refuted in the *Annals of Medicine and Surgery*, (1816, Sept. p. 346. 386.) and subsequently by the Christian advocate of the University of Cambridge in his *Remarks on Modern Scepticism*, &c. The error appears to have arisen in some measure from the want of definition—the word life being used sometimes properly for the power, sometimes improperly for the result. Even if the result of life—the functions of a part, should be called its life, life could not be said to be the result of organisation, but of a power to which organisation is an instrument.

* Horace.

† Cicero, *De Senectute & Quæst. Tuscul.*

‡ A stupid person is honoured with the expressions numb-*scull*, thick-*head*, addle-*pated*, shallow-*pated*, badly furnished in the *upper story*; a clever person with strong-*headed*, long-*headed*, having plenty of *brains*; a madman is said to be wrong or cracked in the *head*, touched in the *brain*, &c. &c.

organs, can perform its functions, and mind continues; but, as in all other organs, when its life ceases, its power to perform its function ceases, and the mind ceases; when causes of disturbance affect it, the mind is affected; if originally constituted defective, the mind is defective; if fully developed and properly acted on, the mind is vigorous; accordingly as it varies with age, is the mind also varied,—the mind of the child is weak and excitable, of the adult vigorous and firm, and of the old man weak and dull, exactly like the body; * and the character of the mind of an individual agrees with the character of his body, being equally excitable, languid, or torpid, evidently because the brain is of the same character as the rest of the body to which it belongs,—the female mind exceeds the male in excitability as much as her body; † the qualities of the mind are also hereditary, ‡ which they could not be, unless they were, like

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* If of children it is said,—" Inter se quas pro levibus noxiis iras gerunt? Quapropter? quia enim qui eos gubernat animus, infirmum gerunt."
Terence. *Hecyra.*

The old man,—" Res omnes timide gelideque ministrat,
Dilator, spe longus, iners—" Horace. *Ars Poetica.*

or in the plainer language of Shakspeare, " Old men have grey beards, their faces are wrinkled, their eyes purging thick amber and plum-tree gum, and they have a *plentiful lack of wit*, together with most weak hams."
Hamlet. Act. 2. Sc. 2.

Mr. Dugald Stewart allows that " In the case of old men, it is generally found that a decline of the faculties keeps pace with the decay of bodily health and vigour. The few exceptions that occur to the universality of this fact only prove that there are some diseases fatal to life which do not injure those parts of the body with which the intellectual operations are more immediately connected." *Outlines of Moral Philosophy.* p. 233.

" Præterea gigni pariter cum corpore, et una
Crescere sentimus, pariterque senescere, mentem." Lucretius. lib. i.

† " Mulieres sunt, ferme ut pueri, levi sententia."—Terence. *Hecyra.*

‡ " Parentibus liberi similes sunt non vultum modo et corporis formam, sed animi indolem, et virtutes, et vitia.—Claudia gens diu Romæ floruit impigra, ferox, superba: Eadem illachrymabilem Tiberium, tristissimum Tyrannum produxit: tandem in immanem Caligulam et Claudium, et Agrippinam, ipsum-

our other qualities, corporeal conditions; and the mind is often disordered upon the disappearance of a bodily complaint, just as other organs, besides the brain, are affected under similar circumstances,—the retrocession of an eruption may affect the lungs, causing asthma, the bowels, causing enteritis, or the brain, causing insanity; phthisis and insanity sometimes alternate with each other, just like affections of other organs. The argument of Bishop Butler, that the soul is immortal and independent of matter because in fatal diseases the mind often remains vigorous to the last, * is perfectly groundless, for any function will remain vigorous to the last if the organ which performs it is not the seat of the disease, nor much connected by sympathy or in other modes with the organ which is the seat of the disease,—the stomach often calls regularly for food and digests it vigorously, while the lungs are almost completely consumed by ulceration. All the cases that are adduced to prove the little dependence of the mind on the brain, are adduced in opposition to the myriads of others that daily occur in the usual course of nature, and are evidently regarded as extraordinary cases by those who bring them forward. An exact parallel to each may be found in affections of every other organ, and each admits of so easy an explanation that it may be always truly said, "Exceptio probat regulam." †

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que demum Neronem, post sexcentos annos desitura."—Gregory, *Conspectus Medicinæ Theoreticæ.* So true is the verse

Et patrum in natos abeunt, cum semine, mores.

* *The Analogy of Religion, natural and revealed, to the Constitution and Course of Nature.* By Joseph Butler, LL.D. Lord Bishop of Durham. p. 33.

† I will not insult the understanding of my readers by showing that we have no authentic instance of the real absence of brain in the cranium of a being possessed of a mind. The records of medicine no less teem with wonders than those of theology. The miracles of the Fathers and of the Romish Church may be matched by cases not only of mind without brain, but of human impregnation without males or by males without testes, and of human fœtuses nourished without communication with the mother.

In

In contending that the mind is a power of the living brain, and the exercise of it the functions of that organ, I contend for merely a physical fact, and no Christian who has just conceptions of the Author of Nature will hesitate to look boldly at nature as she is, lest he should discover facts opposite to the pronunciations of revelation. For the word and the works of the Almighty cannot contradict each other. Lord Bacon accordingly, in a very memorable part of his writings, directs the physical enquirer to be uninfluenced by religious opinions,* as the more independently truth is pursued the sooner will it be gained, and the sooner will the real meaning of the divine statement of natural things, and its identity with physical fact, be established.

The assertion, however, that the mind is a power of the living brain, is not an assertion that it is material, for a power or property of matter cannot be matter.

Neither is it an assertion, that this power cannot be a some-

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In most cases where the mind is *said* to have been vigorous when the state of the body at large or of the brain alone rendered the perfect performance of the cerebral functions improbable in the eyes of the relaters, I believe the mental power has even been greatly overrated,—that because the individual has merely talked collectively he has been imagined sufficient for the exertions of his best health.

Those who thus attempt to prove the *substantial distinctness* of the mind and brain, forget that these arguments are equally strong against what they generally admit,—the *connection* of the mind and brain, and are therefore grounded on what, if true, were violations of the course of nature.

* Si quis animum diligentius advertat, non minus periculi naturali philosophiæ ex istiusmodi fallaci in iniquo fœdere, quam ex apertis inimicitiis, imminere. Tali enim fœdere et societate accepta, in philosophia tantum comprehendi, aucta autem, vel addita, vel in melius mutata, etiam severius et pertinacius excludi. Denique versus incrementa et novas veluti oras et regiones philosophiæ, omnia ex parte religionis, pravarum suspicionum et impotentis fastidii plena esse. Alios siquidem simplicius subvereri, ne forte altior in naturam inquisitio ultra datum et concessum sobrietatis terminum penetret, &c. &c. Quare satis constabat in hujusmodi opinionibus multum infirmitatis, quin et invidiæ et fermenti non parum subesse, &c.—*Cogitata et Visa.* p. 167. 8vo. edition.

thing immortal, subtle, immaterial, diffused through and connected with the brain. A physical enquirer has to do with only what he observes. He finds this power, but attempts not to explain it,—he simply says the living brain has this power, and leaves others at liberty to fancy an hypothesis of this power being a subtle, immaterial, immortal substance, exactly as they fancy life to be a subtle fluid, or perhaps, though very extraordinarily, the same subtle fluid (if subtlety is immateriality and immortality), elucidating the subject no more than in the case of life, and equally increasing the number of its difficulties,* as though we were not *created* beings, or not altogether ignorant what matter is, or of what it is capable and incapable; as though matter exhibited nothing but extension, attraction, and inertness; and as though the Almighty could not, if it seemed good to him, endow it with the superaddition of life, and even of feeling and will.†

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* Locke, (*Second Reply to the Bishop of Worcester*. p. 477. 8vo. edition.) in disparaging philosophical reasons for the immortality of the soul, says,

"Dr. Cudworth affirms that there was never any of the ancients before Christianity that held the soul's future permanency after death, who did not likewise assert its pre-existence." Sterne's fine ridicule of the absurdities introduced by the hypothesis into the Romish church need not be quoted. A French midwife acquaints us that he baptised a little abortion of the magnitude of a beetle, and another of the same breadth but longer. (De la Motte, *Traitè des accouchemens.* p. 201. p. 244.) A good idea of what follows in its train may be collected from Dante's tiresome account of the introduction of the soul into the body, beginning, 'Sangue perfetto che mai non si beve, &c.'—*Purgatorio.* Canto xxv. It is one parent of necromancy, of the belief in ghosts, and of all the popish trumpery respecting purgatory.

† "All the difficulties that are raised against the thinking of matter, from our ignorance or narrow conceptions, stand not at all in the way of the power of God, if he pleases to ordain it so." The faculties of brutes prove "either that God can and doth give to some parcels of matter a power of perception and thinking, or that all animals have immaterial and consequently immortal souls as well as men; and to say that fleas and mites, &c. have immortal souls as well as men, will possibly be looked on as going a great way to serve an hypothesis." Locke, *Second Reply to the Bishop of Worcester.* p. 466. 8vo. edit.

Nor does this assertion imply that the resurrection from the dead is impossible or even improbable. The physical enquirer, finding the mind a power of the brain, and abstaining from hypothesis, must conclude that, in the present order of things, when the brain ceases to live the power necessarily ceases,—that, in the language of scripture, Dust we are and unto dust we all return,—that our being is utterly extinguished and we go back to the insensibility of the earth whence we were taken.* Our consciousness of personality can afford no reason for imagining ourselves immortal and distinct from earth, more than brutes, for this the fly possesses equally with the philosopher about whose head it buzzes.† The moral government of the world, the sublime reach of our acuteness, the great improvableness of our characters,—

> " Our innate pleasing hope, our fond desire,
> Our longing after immortality,
> Our secret dread and inward horror of falling into nought," ‡

completely harmonise with a life hereafter, but fall so short of proof as to have left the wisest of antiquity,—Solomon, Socrates, Cicero, &c. in uncertainty, § when they saw how death reduced us to our pristine elements. The hope of immortality which such reflections, and possibly also the tradition of Enoch's translation, inspired, || assisted by the desire of explaining every thing in some way or other, first, I apprehend, made men attempt to find, in the imagined ethereal essence of the soul, a

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* *Miscellaneous Tracts, &c.* by Richard Watson, D.D. F.R.S. Lord Bishop of Llandaff. Sermon iii. p. 399 sq.

† Heathens have, very consistently with this reason for immortality, given it to the fancied souls of animals: Ulysses is made by Homer to behold the shade of Orion—

> Θῆρας ὁμῦ εἰλεῦντα, κατ' ἀσφοδελὸν λειμῶνα
> Τὺς αὐτὸς κατέπεφνεν ἐν οἰοπολοισιν ὄρεσσι. Odyss. Λ. 571.

‡ Addison, *Cato.* See a full enumeration in Mr. Dugald Stewart's *Outlines*, &c. p. 235 sq.

§ Bishop Watson, l. c. Sermon vi. p. 504 sq.

|| Bishop Watson, l. c. 499.

reason for our not totally perishing as our senses would lead us to suppose. But because we refuse to listen to a mere hypothesis we are not to deny the resurrection. For if a divine revelation pronounce that there shall be *another order of things* in which the mind shall exist again, we ought firmly to believe it, because neither our experience nor our reason can inform us what will be hereafter, and we must be senseless to start objections on a point beyond the penetration of our faculties.* We have a Divine revelation which so pronounces,—not that we are naturally immortal, but that "in Adam (by nature) all die,"—have our being utterly extinguished, and in another order of things,—when the fashion of this world shall have passed away and time shall be no more, that in Christ (by the free, additional, gift of God, granted through the obedience of our Saviour) we shall all again be made alive. A miracle would not have been necessary to convince us of a truth discoverable by sense and reason. That the promises of revelation are the proper and *only* foundation of our hopes of immortality, was the opinion of the late Regius Professor of Divinity in the University of Cambridge, whose gigantic intellect and sincere love of truth render his opinions weightier than the decrees of councils.—"I have no hope of a future existence," says he, "except that which is

* "Nor can we be obliged, where we have the clear and evident sentence of reason, to quit it for the contrary opinion, under a pretence that it is a matter of faith, which can have no authority against the plain dictates of reason. But there are many things wherein we have very imperfect notions, or none at all; and other things, of whose past, present, or future existence, by the actual use of our faculties, we can have no knowledge; these, as being beyond the discovery of our natural faculties, and above reason, are, when revealed, the proper matter of faith. Thus, that part of the angels rebelled against God, and thereby lost their first happy state, and that the dead shall rise and live again; these and the like, being beyond the discovery of reason, are purely matters of faith, with which reason has nothing directly to do."—Locke, *Essay on Human Understanding*. iv. ch 18.

Reason's province is only to examine the proofs of the authenticity of revelation, and faith must thus be founded on reason.

grounded on the truth of Christianity." * While those are to be pitied who think there can be any thing like an argument against a future life in another order of things, if declared by revelation, I am deeply hurt that others should think it necessary to attempt rendering the pronunciations of scripture more probable by an hypothesis which is at best but the remains of unenlightened times, † and require any assurance besides that of the Gospel

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* *Anecdotes of the Life of* Richard Watson, D.D. F.R.S. late Lord Bishop of Llandaff.—Vol. i. p. 107. See also a very decisive passage, beginning, "As a Deist I have little expectation; as a Christian I have no doubt, of a future state," in his *Apology for the Bible*. Letter x. near the end.

Locke argues, "that all the great ends of religion and morality are secured barely by the immortality of the soul, without a necessary supposition that it is immaterial."—*First Reply*. p. 34.

Mr. Dugald Stewart concedes that "the proper use of the doctrine of the immateriality of the soul is not to demonstrate that the soul is physically and necessarily immortal." l. c. p. 227. The celebrated Dr. Rush, of America, remarks upon this subject, "that the writers in favour of the immortality of the soul have done that truth great injury by connecting it necessarily with its immateriality. The immortality of the soul depends upon the will of the Deity, and not upon the supposed properties of spirit. Matter is in its own nature as immortal as spirit. It is resolvable by heat and moisture into a variety of forms; but it requires the same almighty hand to annihilate it, that it did to create it. I know of no arguments to prove the immortality of the soul but such as we derive from the Christian revelation."—*Medical Inquiries and Observations*. vol. ii. p. 15.

† The more uninformed the age, the greater the disposition to explain every thing. The savage personifies the winds and the heavenly bodies; the ancients fancied all matter endowed with a spirit (spiritus intus alit). Philo and Origen maintain that the stars are so many souls, incorruptible and immortal. In old modern writings, even in those of the father of experiment and observation,—Lord Bacon, the properties of matter are referred to spirits:—an acid acts by its spirit. All these notions still exist among the vulgar; and the last remaining among the better informed, though it too is rapdly dying away, relates to mind. Those who upbraid others for refusing their assent to this hypothesis, may recollect that Anaxagoras and many more were accused of atheism and impiety, because they denied that the heavenly bodies were animated and intelligent. Even in the last reign some viewed the Newtonian doctrines as irreligious.

which "has brought life and immortality to light." * They should reflect that the belief of an immaterial substance removes no imagined difficulty, as the resurrection will be positively of body, and that therefore our minds will appear as much a property of body hereafter as at present. The sound and excellent Paley, following Locke who shews in his third letter to Bishop Stillingfleet that the Scriptures do not say our identical bodies (σώματα) will be raised, but merely οἱ νεκροὶ or πάντες, with bodies, draws, in his sermon on the state after death, the following conclusions from various intimations in the New Testament :—

"First, that (at the resurrection) we shall have bodies.

"2. That they will be so far different from our present bodies, as to be suited, by that difference, to the state and life into which they are to enter, agreeably to that rule which prevails throughout universal nature, that the body of every being is suited to its state, and that when it changes its state it changes its body.

Materialist is as good a word as any other to brand those with from whom we differ, but materialism in its true acceptation signifies the preposterous doctrine of no first cause,—that all has been produced ex fortuita atomorum collisione. The whole tenor of Scripture implies that *we* are bodies endowed with certain properties; and those passages from which our being a distinct immaterial substance is inferred, may be easily explained by the figurative style of the sacred writings, by the necessary adoption of the language of the times, and by the influence of the national opinions and prejudices of the writers on their mode of expressing divine truths. Without due allowance, we might deem it impious to deny that "the round world cannot be moved;" that the sun "pursues its course;" that Naaman's leprosy (a condition of body) was a real substance, and as such clave unto Gehazi; that Adam surely died on the very day he tasted the forbidden fruit; that the winds possessed sense when Christ said, Peace, be still; and that Saul's melancholy and the cases of insanity and epilepsy related in the New Testament were possessions by demons, which are pronounced in another part to be nothing in the world. And on these points I strongly recommend the study of the Rev. Hugh Farmer's original and admirable works, especially his *Essays on the Demoniacs of the New Testament*, and *on Christ's Temptation.* Without due allowance, what absurdities might be inferred from the use of the word heart?

* 2 Timothy. i. 10.

"3. That it is a question by which we need not be at all disturbed whether the bodies with which we shall arise be new bodies, or the same bodies under a new form; for,

"4. No alteration will hinder us from remaining the same, provided we are sensible and conscious that we are so, any more than the changes which our visible person undergoes even in this life, and which from infancy to manhood are undoubtedly very great, hinder us from being the same, to ourselves and in ourselves, and to all intents and purposes whatsoever.

"Lastly, That though from the imperfection of our faculties, we neither are, nor without a constant miracle upon our minds, could be made able to comprehend the nature of our future bodies, yet we are assured that the change will be infinitely beneficial; that our new bodies will be infinitely superior to those which we carry about with us in our present state."*

The Archdeacon's fourth conclusion removes an objection that might suggest itself to some. St. Paul declares the resurrection to be "a mystery:" it will in truth be a miracle, and vain were the enquiry "how can these things be?" On these subjects I wish to touch with modesty and reverence, and if I have written a syllable that can be proved contrary to Scripture or to the Articles of the Church of England, I acknowledge it false and declare it unsaid. The view of nature is really a revelation, and cannot without impiety be thought contradicted by any inspired declaration. I think with Bishop Watson that the farther general science extends as years pass on, the better will the volumes of our faith be understood. Next to the irreligious lives of many professed

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* *Sermons on several Subjects*, by the late Rev. W. Paley, D.D. S. 3. p. 96. These are a small body of divinity, and having been bequeathed by him to his parishioners, probably contain his mature convictions.

It is the doctrine of the Church of England that "all men shall rise with their bodies." Enoch and Elijah were translated bodily. Nay, as far as our Church acknowledges the human nature of Christ, it believes that he ascended into heaven and there sits, with "his body, with *flesh*, *bones*, and all things appertaining to the perfection of man's nature." (Art. IV.)

Christians, nothing has contributed more to the infidelity of thoughtless men than the pretence that various opinions are necessarily connected with the grand doctrines of salvation. The elucidation of the first chapter of Genesis by geology, and the erroneous views taken of it through ignorance of science by a truly good man, were lately displayed in an able article of the *Quarterly Review.*

SECT. VII.

ON THE MOTION OF THE BLOOD.

84. The blood, to whose great and multifarious importance in the system we have slightly alluded, (16) is conveyed, with a few exceptions, (5) into the most internal and extreme recesses. This is proved by the minute injection of the vessels, and by the well known fact of blood issuing from almost every part on the slightest scratch.

85. This purple fluid does not, like an Euripus, ebb and flow in the same parts, as the ancients imagined, but pursues a circular course; so that being propelled from the heart into the arteries, it is distributed throughout the body, and returns again to the heart through the veins. *

86. We shall, therefore, say something at present of the *vessels* which contain the blood; and afterwards, of the *powers* by which they propel and receive it.

87. The vessels which receive the blood from the heart and distribute it throughout the body, are termed *arteries*. These are upon the whole less capacious than

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* Among warm-blooded animals, the egg, especially at the fourth and fifth day of incubation, if placed under a simple microscope, such as the Lyonetian, is most proper to demonstrate the circulation.

Among frogs, the most proper is the equuleus of Lieberkühn, described in the *Mem. de l'Acad. de Berlin.* 1745.

the veins; but in adult and advanced age especially, of a texture far more solid and compact, very elastic and strong.

88. The arteries consist of three *coats:**

I. The exterior, called, by Haller, the *tunica cellulosa propria;* by others, the nervous, cartilaginous, tendinous, &c. It is composed of condensed cellular membrane, externally more lax, internally more and more compact: blood vessels are seen creeping upon it:† it gives tone and elasticity to the arteries.

II. The middle coat consists of transverse fibres,‡ lunated or falciform, and almost of a fleshy nature: hence this has the name of muscular coat, and appears to be the chief seat of the vital powers of the arteries.

III. The inner coat lining the cavity of the arteries is highly polished and smooth. This is much more distinct in the trunks and larger branches than in the smaller vessels.

89. Every artery *originates* either from the pulmonary artery (the vena arteriosa of the ancients), which proceeds from the anterior ventricle of the heart and goes to the lungs; or from the aorta, which proceeds from the posterior ventricle and is distributed throughout the rest of the system. These trunks divide into branches, and these again into twigs.

90. According to the commonly received opinion,

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* For the various opinions respecting the number and differences of the arterial coats, consult among others Vinc. Malacarne, *Della Osservat. in Chirurgia.* Turin. T. ii. p. 103.

† Fr. Ruysch, *Respons. ad ep. problematicam.* iii. Also his *Thesaur. Anat.* iv. tab. 3.

‡ B. S. Albinus, *Annot. Academ.* L. iv. tab. 5. fig. 1.

the united capacity of the *branches* is greater than that of the trunk from which they arise. But I fear that this is too general an assertion, and even that the measure of the diameter has been sometimes improperly confounded with that of the area. I myself have never been able to verify it, although my experiments have been frequently repeated, and made, not on vessels injected with wax, but on the undisturbed vessels of recent subjects, on the innominata and its two branches —the right carotid and subclavian, on the brachial and its two branches—the radial and ulnar.*

The inconstancy of the proportion between the capacity of the branches and trunks is clearly shewn by the various size of the vessels under different circumstances, v. c. by the relative capacity of the inferior thyroid artery in the infant and the adult; of the epigastric artery and also of the uterine vessels in a virgin and a woman far advanced in pregnancy; of the omental vessels during the repletion and vacuity of the stomach.†

91. The arteries, after innumerable divisions and important anastomoses ‡ connecting different branches, *terminate* at length in the beginning of the veins. By this means, the blood is conveyed back again to the heart. The distinction between artery and vein at the point of union, is lost.

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* See also J. Theod. Van Der Kemp, *De Vita*. Edinb. 1782. 8vo. p. 51.

† This is remarkably observable in the adult stag, by comparing the areæ of the external carotid and its branches, during the spring, before the horns have attained their full growth but are still covered with their downy integuments (called in our language, *der Bast*), with such as they are after this covering has fallen off.

‡ Ant. Scarpa, *Sull' Aneurisma*. Pav. 1804. fol. cap. 4.

In the present state of our knowledge, the umbilical vessels are to be regarded as the only exception to the termination of arteries in veins. We shall shew that they are connected with the uterine vessels by the intervention of a spongy substance, called parenchyma.

92. Another description of vessels arise universally from the arteries and are called *colourless*, from not containing pure blood, either on account of their minuteness, or of their specific irritability which causes them to reject that fluid. These are the *nutrient* and other *secretory* vessels: of which hereafter.

93. The blood conveyed from the heart by the arteries is carried back by the *veins*.

These are very different in function and structure from the arteries, excepting however the minutest of both systems, which are indistinguishable.

94. The veins, excepting the pulmonary, are upon the whole more capacious than the arteries; are more ramified; much more irregular in their course and division; in adult age, softer and more elastic, but still very firm and remarkably expansile.

95. Their *coats* are so much thinner that the blood appears through them. They are likewise less in number, being solely a cellular external, somewhat resembling the nervous of the arteries; and a very polished internal, also nearly agreeing with that of the arteries.

A muscular coat exists in the largest trunks only.

96. The interior coat forms, in most veins of more than a line in diameter, very beautiful valves, of easy play, resembling bags, generally single, frequently double, and sometimes treble, so placed, that the fundus lies towards the origin of the vein, the limbus towards the heart.

These valves are not found in some parts; not in the brain, heart, lungs, secundines, nor in the system of the vena portæ.

97. The twigs, or, more properly, the radicles, of the veins, unite into branches, and these again into six principal trunks: viz. into the two cavæ, superior and inferior; and the four trunks of the pulmonary vein (the arteria venosa of the ancients).

The vena portæ is peculiar in this, that, having entered into the liver, it ramifies like an artery, and its extreme twigs pass into the radicles of the inferior cava, thus coalescing into a trunk.

98. That the blood may be properly distributed and circulated through the arteries and veins, nature has provided the *heart,** in which the main trunks of all the blood vessels unite, and which is the grand agent and mover of the whole system,—supporting the chief of the vital functions with a constant and truly wonderful power, from the second or third week after conception to the last moment of existence.

99. The heart alternately receives and propels the blood. Receiving it from the body by means of the superior and inferior vena cava, and from its own substance through the common valvular† orifice of the coronary veins, it conveys that fluid into the anterior sinus and auricle; and thence into the corresponding ventricle, which, as well as the auricle, communicates

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* W. Cowper, *Myotomia Reformata.* (Posth.) Lond. 1724. Fol. max. Tab. xxxvi—xl.

† Casp. Fr. Wolff on the origin of the large coronary vein, *Act. Acad. Scient. Petropol.* 1777. P. i.

Petr. Tabarrani on the same subject, *Atti di Siena.* Vol. vi.

with both orders of its own vessels by the openings of Thebesius. *

100. From this anterior, or, in reference to the heart of some animals, right, ventricle, the blood is impelled through the pulmonary artery into the lungs: returning from which, it enters the four pulmonary veins and proceeds into their common sinus and the left, or, as it is now more properly termed, posterior auricle. †

101. It flows next into the corresponding ventricle; and then passing into the aorta, is distributed through the general arterial system and the coronary vessels of the heart. ‡

102. Having proceeded from the extreme twigs of the general arterial system into the radicles of the veins, and from the coronary arteries into the coronary veins, it finally is poured into the two venæ cavæ, and then again pursues the same circular course.

103. The regularity of this circular and successive motion through the cavities of the heart is secured, and any retrograde motion prevented, by the *valves* which are placed at the principal openings, viz. at the openings of the auricles into the ventricles, and of the ventricles into the pulmonary artery and aorta.

104. Thus the ring, or venous tendon, which forms the limit of the anterior auricle and ventricle, descending into the latter cavity, becomes these tendinous valves. § These were formerly said to have three apices, and

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* Respecting these openings consult among others J. Abernethy, *Philos. Trans.* 1798. p. 103.

† James Penada, *Memorie della Societa Italiana.* T. xi. p. 555.

‡ Consult Achill. Mieg, *Specimen ii. Observationum Botanicarum,* &c. Basil. 1776. 4to. p. 12 sq.

§ Eustachius, Tab. viii. fig. 6.—tab. xvi. fig. 3. Santorini. Tab. Posth. ix. fig. 1.

were therefore called triglochine or *tricuspidal:* they adhere to the fleshy pillars, or, in common language, the papillary muscles.

105. In a similar manner, the limits of the posterior auricle and ventricle are defined by a ring of the same kind, constituting two valves, which, from their form, have obtained the appellation of *mitral.* *

106. At the opening of the pulmonary artery † and aorta ‡ are found the triple *semilunar* or sigmoid valves,§ fleshy and elegant, but of less circumference than the mitral.

107. It is obvious how these valves must prevent the retrocession of the blood into the cavæ. They readily permit the blood to pass on, but are expanded, like a sail, against it, by any attempt at retrograde movement.

108. The *texture* of the heart is peculiar: fleshy, indeed, but very dense and compact, far different from common muscularity.|| It is composed of fasciculi of fibres, more or less oblique, here and there singularly branching out, curiously contorted and vorticose in their direction, lying upon each other in strata, closely interwoven between the cavities, and bound by four cartilaginous bands to the basis of the ventricles, which are thus supported and distinguished in their texture from the fibres of the auricles. **

* Eustachius, Tab. xvi. fig. 6.

† Eustachius, Tab. xvi. fig. 4.

‡ Eustachius, Tab. xvi. fig. 5. Morgagni, *Advers. Anat.* i. Tab. iv. fig. 3. Santorini, l. c.

§ Consult Hunter, who treats very minutely of the mechanism of these valves in his work *On the Blood*, &c. p. 159.

|| Leop. M. A. Caldani, *Memorie lette nell' Acad. di Padova.* 1814. p. 67.

** Casp. F. Wolff, *Act. Acad. Scientiar. Petropol.* for the year 1780 sq.

109. These fleshy fibres are supplied with very soft nerves* and an immense number of blood vessels, which arise from the coronary arteries, and are so infinitely ramified,† that Ruysch described the whole structure of the heart as composed of them.‡

110. The heart is loosely contained in the *pericardium.*§ This is a membraneous sac, arising from the mediastinum, very firm, of the same figure as the heart, and moistened by an exhalation from the arteries of that organ. Its importance is evinced by its existence being, in red blooded animals, as general as that of the heart; and by our having only two instances on record of its absence in the human subject.||

111. By this structure, the heart is adapted for perpetual and equable motions, which are an alternate systole and disastole, or contraction and relaxation of the auricles and ventricles in succession.

112. Thus, as often as the auricles contract to impel the blood of the venæ cavæ and pulmonary veins into the ventricles, these are at the same moment relaxed, to receive the blood: immediately afterwards, when the distended ventricles are contracting to impel the blood into the two great arteries, the auricles relax and receive the fresh venous supply.

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* Scarpa, *Tabulæ Neurologicæ ad illust. Hist. Anat. cardiac. nervor.* Tab. iii. iv. v. vi.

† Ruysch, *Thesaur. Anat.* iv. Tab. iii. fig. 1, 2.

‡ Brandis has proposed an ingenious hypothesis to explain the use of so great an apparatus of coronary vessels. *Versuch über die Lebenskraft.* p. 84.

§ Haller, *Elementa Physiol.* T. i. tab. i.

Nicholls, *Philos. Trans.* Vol. lii. P. i. p. 272.

|| Littre, *Hist. de l'Academie des Sc. de Paris.* 1782. p. 37. Baillie, *Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge.* T. i. p. 91.

113. The systole of the ventricles, upon which is said to be spent one third of the time of the whole action of the heart, is performed in such a way, that their external portion is drawn towards their septum, and the apex of the heart towards the base.* This at first sight seems disproved by the circumstance of the apex striking against the left nipple and consequently appearing elongated,—a circumstance, however, to be attributed to the double impetus of the blood flowing into the auricles and expelled from the ventricles, by which the heart must be driven against that part of the ribs. (A)

114. The impulse imparted by the heart to the blood, is communicated to the arteries, so that every systole of the heart is very clearly manifested in those arteries which can be explored by the fingers and exceed $\frac{1}{6}$ of an inch in diameter, and in those also whose pulsation can be otherwise discovered, as in the eye and ear. The effect upon the arteries is called their disastole, and is correspondent and synchronous with the systole of the heart.

115. The quickness of the heart's pulsations during health varies indefinitely; chiefly from age, but also from other conditions which at all ages form the peculiar health of an individual; so that we can lay down no rule on this point. I may, however, be permitted to mention the varieties which I have found in our climate † at different ages, beginning with the new-born

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* Consult Ant. Portal, *Mémoires sur la Nature & le Traitement de plusieurs Maladies.* T. ii. 1800. p. 281.

† My observations differ but little from those made by Heberden in England, *Med. Trans.* vol. ii. p. 21 sq.

infant, in which, while placidly sleeping, it is about 140 in a minute.

Towards the end of the first year, about	124
. . . . second . . .	110
. . . . third and fourth	96
When the first teeth begin to drop out .	86
At puberty	80
At manhood	75
About sixty	60

In those more advanced, I have scarcely twice found it alike.

116. The pulse is, *cæteris paribus*, more frequent in women than men, and in short than tall persons. A more constant fact, however, is its greater slowness in cold climates.* Its greater frequency after meals and coition, during continued watchfulness, exercise, or mental excitement, is universally known. (B)

117. The heart rather than the arteries is to be regarded as the source of these varieties.

Its action continues in this manner till death, and then all its parts do not, at once, cease to act; but the right portion, for a short period, survives the left.†

For since the collapsed state of the lungs impedes the course of the blood from the right side, and the veins must be turgid with the blood just driven into

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* J. H. Schonheyder, *De Resolutione et Impotentia motus Muscularis.* Hafn. 1768. p. 15. With which work compare the observations of F. Gabr. Sulzer, *Naturgesch. des Hamsters.* p. 169.

† Stenonis, *Act. Haffniens.* T. ii. p. 142.

Sometimes, though rarely, it happens that the right portion of the heart, oppressed with too much blood, becomes, contrary to what usually takes place, paralysed before the left. This I have more than once observed on opening living mammalia, particularly rabbits.

them from the arteries, it cannot but happen that this blood, driving against the right auricle, must excite it to resistance for some time after the death of the left portion of the heart.

118. This congestion on the right side of the heart affords an explanation of the small quantity of blood found in the large branches of the aorta. Weiss,* and after him Sabatier,† ascribe to this cause likewise the comparatively larger size‡ of the right auricle and ventricle in the adult dead subject especially.

119. The motion of the blood is performed by these two orders of vessels in conjunction with the heart. Its celerity in health cannot be determined: for it varies not only in different persons, but in different parts of the same person. Generally, the blood moves more slowly in the veins than in the arteries, and in the small vessels than in the large trunks. But these differences have been overrated by physiologists.

The mean velocity of the blood flowing into the aorta, is usually estimated at eight inches for each pulsation, or at fifty feet in a minute.

120. Some have affirmed that the globules of the cruor move more in the axis of the vessels, and with greater rapidity, than the other constituents of the blood. I know not whether this rests upon any satisfactory experiment, or upon an improper application of the laws of hydraulics; improper, because

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* J. N. Weiss, *De Dextro Cordis Ventriculo post mortem ampliori.* Altorf. 1767. 4to.

† Ant. Chaum. Sabatier, *In vivis animalibus Ventriculorum Cordis eadem capacitas.* Paris. 1772. 4to.

‡ Sam. Aurivilius, *De Vasorum Pulmonal. & Cavitat. Cordis inæquali amplitudine.* Gotting. 1750. 4to.

it is absurd to refer the motion of the blood through living canals, to the mere mechanical laws of water moving in an hydraulic machine. I have never observed this peculiarity of the globules. My persuasion is still more certain that the globules pass on with the other constituents of the blood, and are not rotated around their own axis,—that besides the *progressive*, there is no *intestine*, motion in the blood; although indeed there can be no doubt that the elements of this fluid are occasionally divided, where it is variously impelled according to the different direction, division, and anastomoses of the vessels.

121. The *powers* of the sanguiferous system are now to be examined: first, those of the heart, by far the greatest of all; afterwards, those which are only subsidiary, though indeed highly useful.

122. That the powers of the heart cannot be accurately calculated is clear, upon reflecting that neither the volume of the blood projected at each pulsation, nor the celerity nor distance of its projection, much less the obstacles to the powers of the heart, can be accurately determined.

123. A rough calculation may be made by taking every probable conjecture together: v. c. if the mean bulk of the blood is considered as 10 pounds, or 120 ounces; the pulsations 75 in a minute, or 4500 in an hour; and the quantity of blood expelled from the left ventricle at each contraction, as two ounces; it follows that all the blood must pass through the heart 75 times every hour. The impetus of the blood passing from the heart, may be conceived by the violence and altitude of the stream projected from a large wounded artery situated near it. I have seen

the blood driven to the distance of at least five feet from the carotid of an adult and robust man.*

124. This wonderful, and, while life remains, constant, strength of the heart, is universally allowed to depend on its *irritability,* (41) in which it very far surpasses, especially as to duration,†(98) every other muscular part.‡

That the parietes of the cavities are excited to contraction by the stimulus of the blood, is proved by the experiment of Haller, who lengthened at pleasure the motion of either side of the heart, by affording it the stimulus of the blood for a longer period than the other.§ (C)

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* The experiments of Hales, in which the blood was received into very long glass tubes fixed to the arteries of living animals, and the length of its projection measured, are indeed beautiful, like every thing done by this philosopher, who was by nature calculated for such enquiries. But if the force of the heart is to be estimated in this way, we must take into account the pressure of the column of blood contained in the tube and gravitating upon the left ventricle. The result of Hales's calculations was, that the blood being projected from the human carotid seven feet and a half, and the surface of the left ventricle being fifteen square inches, a column of blood, weighing 51.5 lbs. was incumbent upon the ventricle and overcome by its systole.—*Statical Essays.* vol. ii. p. 40. London. 1733. 8vo.

† Thus, to say nothing of the phenomena so frequently observed in the cold-blooded amphibia and fishes, I lately found the heart of the chick beat for twelve hours, in an egg, on the fourth day of incubation.

‡ Consult Fontana, who treats of this prerogative of the heart minutely in his *Ricerche sopra la Fisica animale,* and limits it too much. Haller answered him in the Literary Index of Gottingen.

§ Haller on the motion of the heart from stimulus, *Comment. Soc. Scient. Gottingens.* Tom. i.

G. E. Remus, *Experimenta circa circulat. sanguin. instituta.* Gotting. 1752. p. 14. 4to.

125. Since a supply of nerves and blood is requisite to the action of the voluntary muscles, it has been enquired whether these are requisite to the heart also.*

The great influence of the *nerves* over the heart, is demonstrated by the size of the cardiac nerves, and by the great sympathy between the heart and most functions, however different. A convincing proof of this, is the momentary sympathy of the heart during the most perfect health† with the passions, and with the *primæ viæ* in various disorders. But the great importance of the blood to the irritability of the heart, is evident from the great abundance of vessels in its muscular substance.

Nevertheless it is very probable, that the importance of the nerves in this respect is greater in the voluntary muscles, and of the blood in the heart.

126. Besides these powers of the heart, there is another, which is mechanical, dependent on structure, and greatly contributing, in all probability, to sustain the circulation. For when the blood is expelled from the contracted cavities, a vacuum takes place, into which, according to the common laws of *derivation*, the neighbouring blood must rush, being prevented, by means of the valves, from regurgitating.‡ (D)

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* On this dispute consult R. Forsten, *Quæstion. select. Physiol.* Lugd. Bat. 1774. 4to.

J. B. J. Behrend, *Dissert. qua demonstratur cor nervis carere.* Mogunt. 1792. 4to.; and on the other side, J. Munnik, *Observationes variæ.* Groning. 1805. 4to. Lucæ, l. c. p. 37. tab. ii.

† And how much more so when the heart is diseased, is shewn in Caleb Hillier Parry's *Inquiry into the Symptoms and Causes of the Syncope Anginosa, commonly called Angina Pectoris.* p. 114. Bath. 1799. 8vo.

‡ Andr. Wilson, *Inquiry into the moving powers employed in the Circulation of the Blood.* Lond. 1774. 8vo. p. 35 sq.

127. We must now enquire what powers are exerted by other organs in assisting the circulation. The existence of some *secondary* powers and their ability to assist, or even in some cases to compensate for, the action of the heart, are proved by several arguments: v. c. the blood moves in some parts to which the influence of the heart cannot reach,—in the vena portæ and placenta; not to mention instances of the absence of the heart.*

128. The principal of these powers is the function of the *arteries*, not easy indeed to be clearly understood and demonstrated. 1. They have a muscular coat. (E) 2. That they are irritable, has been proved by repeated experiments. † 3. The size of the soft nerves arising from the sympathetic, and surrounding the larger arterial branches, particularly in the lower part of the abdomen, ‡ argues the importance of these vessels in assisting the motion of the blood. §

129. The arteries pulsate, and indeed violently, so

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* See v. c. C. W. Curtius. *De monstro humano cum infante gemello.* Lugd. Bat. 1762. 4to. p. 39. W. Cooper, *Philos. Transact.* vol. lxv. p. 316. Haller, *Opera Minora.* T. iii. p. 33. C. Chr. Klein, *Descriptio monstrorum quorundam.* Stuttg. 1793. 4to.

† Walter Verschuir, *De arteriar. et venar. vi irritabili; ejusque in vasis excessu; et inde oriunda sanguinis directione abnormi.* Groning. 1766. 4to.

Rich. Dennison, *Diss. arterias omnes et venarum partem irritabilitate præditas esse.* Edinb. 1775. 8vo.

Chr. Kramp, *De vi vitali arteriarum.* Argent. 1785. 8vo.

‡ Observe for instance, in Walter's *Tabulæ nervor. thorac. et abdominis*, the right hepatic, Tab. ii. O. Tab. iii. *l.*—the splenic, tab. ii. P. Tab. iii. *m.* tab. iv. *o.*—the superior mesenteric, Tab. ii. Q. Tab. iii. *s.*—the inferior mesenteric, Tab. ii. T.—and many others. Compare Soemmerring, *De c. h. fabrica.* T. iv. p. 362.

§ Haller, *De Nervor. in arterias imperio.* Gotting. 1744. 4to. *Lucæ*, l. c.

that if, v. c. we place one leg over the other knee, we find not only that it, but even a much greater weight, may be raised by the pulsation of the popliteal. Hence an alternate systole and diastole, corresponding with those of the heart, have long been assigned to them. But this, although commonly believed on the evidence of sense, is open to much question:* it may be asked, especially, whether this pulsation is referrible to the power of the artery, or only to the impulse given by the heart to the blood propelled into the aorta.

130. And indeed, after all, it appears that the *diastole* of an artery is owing to the blood,—to a lateral distention given by the impetus of the blood, so that the coats are expanded; and the vessel, by its elasticity, the next moment reacquires its natural thickness. To the same impulse may be ascribed the lateral motion of the axis, observable in the larger arteries, if serpentine and lying in loose cellular substance.(F)

The genuine *systole*, produced by a contraction of their substance, scarcely occurs, probably, while the heart acts with sufficient vigor; but when they are unusually stimulated, or if the action of the heart fails or is impeded by severe disease, then indeed the arteries may supply its place and propel the blood by their own vital energy,

131. Since Whytt† and other illustrious physiolo-

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* T. Kirkland, *Inquiry into the present state of Medical Surgery*. London. 1783. 8vo. vol. i. p. 306 sq.

† *Physiological Essays, containing an inquiry into the causes which promote the circulation of the fluids in the very small vessels of animals*, &c. &c. Second Edition. Edinb. 1761. 12mo.

H. v. d. Bosch, *Uber das Muskelvermögen der Haargefässgen*. Munster. 1786. 8vo.

gists have been convinced that the influence of the heart could not reach the extreme arteries and the origins of the veins, they have ascribed the progression of the blood in those vessels to a kind of *oscillation*, and have happily employed this to demonstrate the nature of inflammation. Many kinds of phenomena, both physiological, as those regarding animal heat, and pathological, as those observed in spasms and particularly in fevers, favour the supposition of this oscillatory faculty, though it is not demonstrable to the eye. (G)

132. It remains now to enquire into the aid given to the returning blood by the *veins*, not alluding at all to their radicles. We should conclude at first sight that they have less active power* than the rest of the sanguiferous system, and that the return of their purple blood to the heart is chiefly ascribable to the impetus a tergo of the arterial blood, and to their valvular structure which prevents any reflux. The efficacy of the valves in this point of view, is shewn by the distentions and infarctions of the veins in the lower part of the abdomen, which are found destitute of valves.†

The existence of vital powers in the venous trunks is probable,‡ from the example of the liver and pla-

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* What is commonly, but improperly, called the *venous pulsation*, observable on opening living animals and in some morbid affections, and also under a violent effort, does not correspond with the action of the heart, but with respiration; since if an expiration is unusually deep and lengthened, and the reflux of the blood to the lungs thus impeded, the jugular vein swells as far as the brain, the subclavian as far as the basilic, and the inferior cava as far as the crural.

† G. E. Stahl, *De vena portæ porta malorum.* Halæ. 1698. 4to.

‡ Lister, *De humoribus.* p. 25.

centa (127), and from experiments instituted on living animals. We formerly mentioned the muscular appearance in the extreme veins near the heart (95). (H)

133. These are the chief powers which move the blood and depend upon the structure and vitality of the sanguiferous system: we say nothing of the effect of gravity, attraction, and other powers, common to all matter. The more remote assistance derived after birth from particular functions, v. c. respiration and muscular motion, will appear in our account of those functions.

NOTES.

(A) Dr. W. Hunter first accounted for this in 1746.

"The systole and diastole of the heart, simply, could not produce such an effect; nor could it have been produced, if it had thrown the blood into a straight tube, in the direction of the axis of the left ventricle, as is the case with fish, and some other classes of animals: but by throwing the blood into a curved tube, viz. the aorta, that artery, at its curve, endeavours to throw itself into a straight line, to increase its capacity; but the aorta being the fixed point against the back, and the heart in some degree loose and pendulous, the influence of its own action is thrown upon itself, and it is tilted forwards against the inside of the chest." *

Dr. Barclay has the following passage on this point.

"When the blood is forced into the arteries, their curvatures, near where they issue from the ventricles, are from their distention lengthened and extended towards straight lines; and, causing the heart to participate in their motions, compel it to describe

* *Treatise on the Blood,* &c. by John Hunter. p. 146. Note.

the segment of a circle, when the apex moving atlantad and sinistrad, is made to strike against the left side. The same kind of motion having also been observed by the celebrated Haller, in distending the left or systemic auricle, it must follow, that the stroke which is given to the side, may be the effect of two distinct causes, either acting separately, or in combination; but acting on a heart obliquely situated, as ours is, in the cavity of the thorax, where the aspect of the base is atlantad and dextrad, and that of the apex sinistrad and sacrad. In combination, as the first of the two, by removing the pressure, will facilitate the influx of the venous blood into the left or systemic auricle, which is situated dorsad; so the second, by the influx of blood into the auricle, will contribute in its turn to facilitate the circular motion of the heart, proceeding from the arteries." *

(B) It is commonly believed, that the pulse of every person is quicker in the evening than in the morning, and some have supposed an increase of quickness also at noon. Upon these suppositions Cullen builds his explanation of the noon and evening paroxysms of hectic fever,† regarding them as merely aggravations of natural exacerbations. The existence of the noon paroxysms is doubtful, and the evening one cannot be so explained, if the writer of a paper in the Edinbugh Journal is correct.‡ His observations show the pulse to be slower in the evening, and quicker in the morning.

(C) The heart, however, of frogs, for instance, contracts and relaxes alternately, for a length of time, when out of the body and destitute of blood.

(D) The influence of this vacuum first pointed out by Dr. Andrew Wilson, and conceded by John Hunter, has been lately very ably displayed by Dr. Carson of Liverpool. §

The quantity of the blood, the length of its course, and the

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* *The Muscular Motions of the Human Body.* p. 567.

† *Practice of Physic.*

‡ Robert Knox, M.D. *Edinburgh Medical and Surgical Journal.* 1815.

§ *An Inquiry into the Causes of the Motion of the Blood.* 1815.

various obstacles opposed to its progress, render it unlikely that the mere propulsive power of the heart is sufficient to maintain the circulation perpetually. But great assistance must be given by the vacuum which takes place in all the cavities of the organ, when the contraction of the muscular fibres is over. The blood is thus drawn into each relaxed cavity, and the heart performs the double office of a forcing and a suction pump. The rapid but quiet motion of the blood in the veins is thus accounted for and would otherwise be inexplicable. The situation of the valves of the heart is also accounted for. There are valves between the auricles and ventricles, and at the mouths of the two great arteries, because behind each of these four openings is a cavity of the heart, alternately dilating and affording a vacuum, into which, without valves, the blood would be drawn retrograde. At the venous openings of the auricles no valves exist, because they do not open from a cavity of the heart,—from a part ever experiencing a vacuum, and therefore the blood cannot, when the auricles contract, move retrograde, but will necessarily pass forwards into the ventricles, which at that moment are offering a vacuum. The inferior elasticity and irritability of the veins are also explained. If veins were capable of contracting equally with arteries, on the diminution of their contents, the suction influence of the heart would constantly reduce their cavities to a smaller capacity than is requisite for their functions. The collapse of the veins by pressure, during the suction of the heart, is prevented by the fresh supply of blood afforded by the vis a tergo, which does exist, although it cannot be considered as of itself adequate to convey the blood back to the right auricle. The reason appears why a tied vein is emptied in the part nearest the heart;—its blood is drawn forwards by suction. We see why a punctured vein does not bleed, if there are other veins to convey the blood discharged from the arteries. The puncture necessarily removes the suction influence of the heart, and the great cause of the progress of the blood in the vein is taken away, while it exists in full force in the other veins of the limb. Were it not for this circumstance, a punctured vein should afford blood very readily. If the chief vein of a limb is wounded, the blood will flow, because it receives the whole blood of the arteries, transmitted by the vis a tergo, no other veins existing into which it can be drawn when the vacuum occurs in the right auricle :- what is a parallel circumstance, if all the veins of a limb are tied, they swell, whereas the ligature of one causes no tumefaction in it. These circumstances are no proof that the vis a tergo is sufficient of itself to bring back the blood, because it is certain that such a vacuum exists, and that such must be the effects of this vacuum upon the movement of the blood: the hemorrhage in the former instance, and the tumefaction in the latter, show a certain force only in the blood, which, were it even sufficient to bring the blood back to the heart, as an experiment of M. Majendie's almost proves it to be,* would not probably long continue so after the assistance of suction was removed.

From the structure of the heart it is clear that the mere alternate relaxation of its parietes enlarges its cavities and forms a vacuum. Experiment proves the same. Dr. Carson put the hearts of some frogs just extracted into water, blood-warm. They were thrown into violent action, and, upon some occasions, projected a small stream of a bloody colour through the transparent fluid. It was thought that a stream of the same kind continued to be projected at every succeeding contraction; but that, after the first or second, it ceased to be observable, in consequence of the liquid supposed to be imbibed and projected, losing its bloody tinge and becoming transparent, or of the same colour with the fluid in which the heart was immersed. The organ was

* A ligature was passed around the whole of a dog's thigh excepting the crural artery and vein. Another was fixed upon the vein. On puncturing the vein, the blood was projected to some distance and continued to be so except when the artery was compressed; and as long as the circulation continued, the stream through the wound in the vein could be regulated at pleasure by compressing or liberating the artery. *Précis Elémentaire de Physologie.* t. ii. p. 323 sq.

felt by the hand to expand during relaxation. He accounts, however, for the full dilatation of the heart upon another principle, upon which it will be impossible to enter at lengh before the next section.

(E) Most Physiologists grant to the capillaries irritability, tonicity, or organic contractility; but some deny that *arteries* possess muscular properties. Bichat's objections are, the absence of contraction on the application of stimuli to them, the much greater resistance of the middle coat to a distending force than of muscular parts, and, lastly, the difference of the changes which it and muscles undergo both spontaneously and by the action of other substances.* Berzelius has multiplied the latter description of proofs.† However this may be, they have certainly vital powers of contraction as fully as any parts of the body. This appears in their various degrees of local dilatation and contraction, under inflammation, passions of the mind, &c.: and if the capillaries alone are allowed to possess organic contractility, it is impossible to say in which point of the arterial track it begins.

Dr. Parry has instituted a number of experiments upon this question. After exactly ascertaining the circumference of arteries in animals, he killed them and again measured the circumference; and after the lapse of many hours,—when life must have been perfectly extinguished, he measured the circumference a third time. Immediately after death, the circumference was found greatly diminished, and on the third examination, it had increased again. The first contraction arose from the absence of the blood which distended the vessel and antagonised its efforts to contract, and it was evidently muscular, or to speak more correctly, organic, contraction, because, when vitality had ceased and this kind of contraction could no longer take place, the vessel was, on the third examination, always found enlarged.

The forced state of distention in arteries was proved by the

* *Anatomie Generale.* T. ii.

† *Animal Chemistry.* p. 25.

contraction immediately occurring on making a puncture in a portion of vessel included between two ligatures. The capacities of arteries are thus always accommodated to the quantity of blood, and this circumstance gives the arterial canal such properties of a rigid tube as enable an impulse at the mouth of the aorta to be instantly communicated throughout the canal. This appears the great office of the contractile powers of arteries, for,

(F) They do not incessantly dilate and contract as many imagine. Dr. Parry, on the most careful examination, could never discover the least dilatation in them, during the systole of the ventricle,—when the pulse is felt. He very properly remarks, that the pulse is felt only when arteries are more or less compressed; under which circumstance, the motion of the blood onwards, by the impulse of a fresh portion from the left ventricle, is impeded: and this effort of the fluid against the obstructing cause gives the sensation called the pulse.*

Dr. Curry, the late senior physician and highly distinguished lecturer on the practice of medicine at Guy's Hospital, concluded, without doubt hypothetically, from some microscopic experiments which he made on inflammation in the presence once of Mr. Charles Bell and once of Mr. Travers, that the circulation is indispensably facilitated by a sort of electric repulsion between the vessels and their contents, and that in inflammatory accumulation, the tone of the vessels being impaired, this repulsion is diminished and the blood passes onwards with difficulty in consequence. My friend and colleague Dr. Scott has obliged me with ample notes taken by himself some years ago, but any one may see in the edition of Dr. Curry's Syllabus, printed in 1810, page 66, the paragraph in which inflammation is referred to the

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* *An Experimental Enquiry into the Nature, Causes, and Varieties of the Arterial Pulse*, &c. by Caleb Hillier Parry, M.D. F.R.S. 1816. Likewise a second work, entitled, *Additional Experiments on the Arteries of warm blooded animals*, &c. by Chas. Hen. Parry, M.D. F.R.S. 1819.—the latter displays as much talent and learning as the former of originality. Dr. Young, in a Croonian lecture, highly worth perusal, *on the Functions of the Heart and Blood Vessels*, reasons forcibly to prove that the muscular power of arteries has very little effect in propelling the blood. *Phil. Trans.* 1809.

neuro-electric state of the vessels, and which contains all the heads of the detail. Mr. Charles Bell has lately published this hypothesis as his own,* but most of the facts adduced by him to prove that the resistance to the blood's progress is removed by a repulsion between it and the vessels may be explained by the suction influence of the heart which he altogether overlooks.

(G) These oscillations are quite imaginary and now disallowed. Although variations of dilatation must affect the course of the blood through vessels, it is difficult to conceive how any regular action of them can assist it.

(H) In a young lady whom I lately attended for chronic catarrh accompanied by violent cough, from which she ultimately recovered, *all* the veins of the back of the hands and fore-arms distinctly pulsated synchronously with the arteries.

The heart of *mammalia* and *birds* has no peculiarity necessary to be mentioned here. In most *amphibious animals*, the arteries spring from the right ventricle, with which the left, that sends off no vessel, communicates: hence their circulation continues under water. The heart of *fish* is extremely small, and has but one auricle and ventricle, the latter propelling the blood to the gills, from which it streams through a large artery. Neither blood vessels nor absorbents have been discovered in *insects*; yet a large tube, close at each end, pulsates in their back. With respect to the *mollusca*: The cuttle fish has three detached hearts, consisting of a ventricle only, two for the gills and one for the aorta; the rest have a single heart, the blood of the cava passing through the gills before it reaches the heart. The same is the case with the *crustacea*, and their heart has no auricle. *Worms* have circulating vessels distinctly contracting and dilating, but no heart. *Zoophytes* have no heart, nor circulating system, properly so called. In the echinus indeed there are two vessels that run along the intestines and are thought to be an aorta and vena cava.

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* *An Essay on the Forces which circulate the blood, being an examination of the difference of the motions of fluids in living and dead vessels.* 1819.

SECT. VIII.

OF RESPIRATION AND ITS PRINCIPAL USE.

134. The *lungs,** closely connected with the heart both by proximity and by relation of function, are two viscera, large after birth, so light as to swim in water, and composed of a spongy, and, as it were, spumous, but pretty tenacious, parenchyma.†

135. They fill each cavity of the chest, and are contiguous to the sacs of the pleuræ, to which, as well as to the other contents of the thorax, they model and apply themselves. (A)

136. They, in a manner, hang from the wind-pipe usually called the aspera arteria, which, besides its interior coat always smeared with mucus, and the subjacent very sensible nervous coat, consists of another which is muscular, surrounding the latter, and divided, except posteriorly, by an indefinite number of cartilaginous falciform arches.

137. The aspera arteria, having entered the thorax, is bifurcated into the two bronchiæ, and these, the more deeply they penetrate into the lobes and lobules of the lungs, are the more and more ramified, losing

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* Soemmerring and Reisseisen, *über die Structur, die Verrichtung und den Gebrauch der Lungen. Zwey Preischriften.* Berlin. 1808. 8vo.

† Respecting all the organs concerned in respiration, consult Corn. J. Van Der Bosch, *Anatomia Systematis Respirationi inservientis Pathologica.* Harlem. 1801. 4to. p. 1—44.

both their cartilaginous rings and muscular coat, until their extreme divisions terminate in those *cells* which form the chief part of the substance of the lungs and alternately receive and emit the air we breathe.

138. The shape and magnitude* of the air cells are various. The former is generally polyedrical. The latter, in regard to surface, is scarcely to be defined:† though, indeed, the *capacity* of the lungs of an adult, during a strong inspiration, is about 120 cubic inches. The immense size to which the lungs may be inflated, when the chest has been opened, has no relation to our present subject.

139. The cells are invested and connected by the common but delicate mucous web,—the general vinculum of the body, and must be carefully distinguished from it. In healthy and very recent lungs, I have found the cells so unconnected that they were distended in one insulated spot by air cautiously inflated into a fine branch of the bronchiæ, while neither the neighbouring cells nor the cellular membrane, which lies between the cells, admitted a single portion. If air is forcibly thrown in, the air cells are ruptured and confounded with the cellular membrane, and both parts distended.

140. The mucous web surrounding the air cells of the lungs is supplied with innumerable blood vessels—divisions of the pulmonary artery and four pulmonary veins, the branches of which accompany the ramifications of the bronchiæ,‡ and, after repeated division,

* Keil, indulging his luxuriant iatro-mathematical genius, assigned more than 1744,000,000 cells to each lung.

† Lieberkühn, with equal exaggeration, made the surface of the cells equal to 1500 square feet.

‡ Eustachius, Tab. xxvii. fig. 13.

form at length a most delicate and immense collection of reticulated anastomoses. This extraordinary net-work, penetrating the mucous web on every side, closely surrounds the air cells, so that the prodigious quantity of blood existing in the pulmonary vessels is separated from the contact of the air by very fine membranes only which Hales estimated as scarely $\frac{1}{1000}$ of an inch in thickness.

141. As each ramification of the bronchiæ possesses a peculiar bunch or lobule of air cells, (139) so again each of these possesses a peculiar system of blood vessels, the twigs of which anastomose in the net-work with one another, but scarcely at all with the blood-vessels of the other lobules, as is proved by microscopic observations on living frogs and serpents, by minute injections, and by the phenomena of vomicæ and other local diseases of the lungs.

142. The common membrane investing the lungs is the chief seat of a remarkable net-work of lymphatic vessels* which run to numerous lymphatic or conglobate glands,† carefully to be distinguished from a neighbouring order of glands, called bronchial, that are supplied with an excretory duct and are of the conglomerate kind.‡

143. The *thorax,* which contains the lungs, has an osseous and cartilaginous base, somewhat resembling a bee-hive, throughout very firm and stable, but in every part more or less moveable for the purpose of respiration.§

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* Mascagni, *Histor. vasor. lymphaticor.* Tab. xx.

† Ibid. Tab. xxi.

‡ Consult Portal, *Mém. de l'Acad. des Scienc. de Paris.* 1780.

§ J. G. Amstein (Præs. Oetinger), *De usu et actione musculor. intercostal.*

This holds good chiefly with the six pairs of true ribs below the first pair, each of which is more moveable than the one above in proportion to the greater length both of its own body and of its cartilaginous appendix. The cartilages are united by a kind of amphiarthrosis to the margin of the sternum on each side. (B)

144. Between the edges of the ribs lie two strata of intercostal muscles, differing in the direction of their fibres, but conspiring to produce the same motion.

At the base of the thorax, the diaphragm* is subtended in the form of an arch. It is a considerable muscle, and, in the words of Haller, next in importance to the heart. Its utility in the mechanical part of respiration was long since shewn, by the excellent experiments of Galen † upon living animals, to depend chiefly on the phrenic nerve. ‡

Its antagonists are the abdominal muscles, especially the two oblique and the transverse.

145. The thorax thus constituted, is, after birth, dilated by inspiration and subsequently reduced to a smaller capacity by expiration.

During the former act, the thorax is enlarged late-

Tubing. 1769. 4to. Theod. Fr. Trendelenburg, Jun. *De sterni costarumque in respiratione vera genuinaque motus ratione.* Gotting. 1779. 4to. Bordenave and Sabatier, *Mém. de l'Acad. des Scienc. de Paris.* 1778.

* Haller, *Icon. Anat.* fascic. 1, Tab. 1.

B. S. Albinus, *Tab. musculor.* Tab. xiv. fig. 5, 6, 7.

J. G. Röderer, *De arcubus tendineis muscul.* progr. 1. Gotting. 1760. 4to.

Santorini, Tab. Posth. x. fig. 1.

† *De Anatomicis Administrationibus.* L. viii. cap. 8. The whole book is full of experiments on respiration.

‡ Ephr. Krüger, *De nervo phrenico.* Lips. 1759.; reprinted in Sandifort's *Thesaurus.* Tom. iii.

Walter, *Tab. nervor. thorac. et abdominis.* Tab. 1. fig. 1. n. 1.

rally and inferiorly, so that the bodies of the six ribs mentioned above (143) are elevated and their inferior margin drawn somewhat outwards, and the arch of the diaphragm at the same time rather depressed and flattened.

I have never observed the inferior extremity of the sternum, in tranquil respiration, to be thrust forwards, as some have asserted. (C)

146. This alternate motion of the chest continues, during health and freedom from restraint, from the hour of birth till death. Its object is, that the lungs may be expanded to admit the air and contracted to expel it, in perpetual alternation. This alternation occurs, in an adult at rest, about 14 times in a minute,—once to about five pulsations of the heart.

147. For man, in common with all warm-blooded animals, cannot long retain the inspired air, but is compelled to discharge it and take in a fresh supply of this pabulum of life, as it always has been denominated.* Common observation teaches, that however pure may be the air entering the lungs, it instantly undergoes remarkable changes, by which it is contaminated and rendered unfit for another inspiration, unless it is renewed.†

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* The antiquity of the notion that air is the *pabulum vitæ*, is seen in the book *de Flatibus,* usually ascribed to Hippocrates. The author regards the aliment as three-fold—victuals, drink, and air: but the latter he calls *vital,* because we cannot dispense with a perpetual supply of it without danger to life.

† Consult Harvey's Dispute upon the necessary renovation of the aërial *succus alibilis,* with the celebrated Astronomical Professor, J. Greaves, in the latter's *Description of the Pyramids in Egypt.* p. 101 sq. Lond. 1646. 8vo. Also the immortal and popular Edm. Halley's *Discourse concerning the means of furnishing air at the Bottom of the Sea in any ordinary Depths.—Phil. Trans.* vol. xxix. No. 349. p. 492 sq.

148. It may be asked what are the changes which the air experiences during inspiration, and which consist not in the loss of elasticity, as was formerly imagined, but in the decomposition of its elements.* For the atmospheric air which we breathe, is a singular mixture of constituents, differing very much in their nature from each other; and, not to mention heterogeneous matters, such as odorous effluvia, various exhalations, and innumerable others which are generally present, is always impregnated with aqueous vapour, electric and magnetic matter, and generally with carbonic acid gas; and is itself composed of unequal parts of two aëriform fluids, viz. 79 of azotic gas, and 21 of oxygen gas in 100.

149. In the first place we know for certain, that at every inspiration (the fulness of which varies infinitely in different men of the same age, breathing placidly †), besides the quantity of azotic gas being somewhat diminished, ‡ the oxygen gas is in a great measure converted into carbonic acid gas, or fixed air; so that the air of expiration, if collected, instantly extinguishes flame and live coals, precipitates lime from lime water, and is specifically heavier than atmospheric air, and rendered unfit for respiration; § it also contains much

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* Fr. Sromeyer, *Grundiss der theoretischen Chemie.* P. ii. p. 619.

† Consult for instance Abildgaard, *Nordisch. Archiv. für Naturkunde, &c.* T. 1. P. i. and ii.

‡ Consult, besides Priestley and others, especially C. H. Peaff, ib. T. iv. P. ii.

§ To discover how frequently an animal could breathe the same portion of air, I took three dogs equal in size and strength, and to the trachea of the first, by means of a tube, I tied a bladder, containing about 20 cubic inches of *oxygen* gas. He died in 14 minutes.

For the second, the bladder was filled with *atmospheric* air. He died in six minutes. For aqueous vapour, which is condensed in a visible form by a temperature of 60° of Fahr.*

150. It is therefore probable, that, during inspiration, the base of the oxygenous portion is set at liberty, and, being united with the arterial blood, is conveyed throughout the system; while the carbon and hydrogen are brought back with the venous blood to the right side of the heart, and thrown off like smoke, as the ancients expressed it, in the lungs.†

The more florid colour of the arterial blood,‡ the darker of the venous, and the analogous appearance of the blood, if exposed to the gases in question, (13) correspond admirably with this theory. Some difficulties, indeed, remain to be solved, v. c. how the carbon can be united in the lungs with the oxygen, so as to fly off in the form of carbonic acid gas. (C)§

151. This perpetual change of elements occurring in

For the third, I employed the carbonised air expired by the second dog. He died in four minutes.

The air of the bladder, upon subsequent examination, gave the common signs of carbonic acid gas. The instruments which I employed are described and illustrated by a plate in the *Medic. Biblioth.* Vol. 1. p. 174 sq. tab. 1.

* J. A. De Luc, *Idées sur la Météorologie.* tom. ii. p. 67. 229.

† Rob. Menzies, *De Respiratione.* Edinb. 1790. 8vo.

H. G. Rouppe on the same subject. Lugd. Batav. 1791. 4to.

J. Bostock, *Versuch über das Athemolen. übers.* von A. F. Nolde. Erf. 1809. 8vo.

‡ J. Andr. Scherer, *Beweis dass* J. Mayow *vor* 100 *Jahren den Grund zur antiphlogistischen Chemie und Physiologie gelegt hat.* p. 104. Edm. Godwyn, *Connexion of Life with Respiration.* Lond. 1788. 8vo. J. Hunter, *On the Blood.* p. 68. J. A. Albers, *Beyträgen zur Anat. und Physiol. der Thiere.* P. 1. p. 108.

§ See J. Brugnatelli, *Elementi di Chimica.* T. 1. p. 155. J. Fr. Gmelin, *De Acidorum origine ex aëre vitali adhuc dubia* in the *Comment. Soc. Reg. Sc. Gotting.* T. xiii.

respiration after birth, we shall show to be very differently accomplished in the fœtus, viz. by means of the connection of the gravid uterus with the placenta. But when the child is born and capable of volition, the congestion of blood that takes place in the aorta, from the obstruction in the umbilical arteries; the danger of suffocation from the cessation of those changes of the blood, in regard to oxygen and carbon, (13) hitherto produced in the uterine placenta; the novel impression of that element into which the child, hitherto an aquatic being, is conveyed; the cooler temperature to which it is now exposed; and the many new stimuli which are now applied, seem to induce new motions in the body, especially the dilatation of the chest and the first inspiration.

The lungs being for the first time dilated by inspiration, open a new channel to the blood, so that, being obstructed in the umbilical arteries, it is derived to the chest.

Since the inspired air becomes hurtful and unpleasant to the lungs by the decomposition which it experiences, I should ascribe to the most simple corrective powers of nature, the subsequent motion by which the poisonous mephitis, as it may be called, is expelled and exchanged for a fresh supply.

The consideration of all these circumstances, especially if the importance of respiration to circulation, demonstrated by the well-known experiment of Hooke,*

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* It bears the epithet Hookian, because it was most adorned by Rob. Hooke. See Th. Sprat, *History of the Royal Society*. Lond. 1667. 4to. p. 232. But it was before instituted by Vesalius, and very much praised for its beauty. *De c. h. Fabrica.* p. 824.

be remembered, will, in my opinion, explain the celebrated *problem* of Harvey * better † than most other attempts of physiologists. (D) ‡

NOTES.

(A) A correct notion can scarcely be formed from this description. The pleura is two closed sacs, one of which lies over each lung, one portion of the sac adhering closely to it, and one lying over this again; the internal surfaces of both portions are always in contact, because, if the parietes of the thorax expand and draw with them the external portion, the lung at the same time expands with air and forces out the internal in the same degree. It is commonly said that a portion of fluid (not vapour) exists in serous membranes for the purpose of lubrication. The late Dr. Marshal, however, proved that this is not the case, but that whenever fluid is discovered, we must regard it as the effect of either disease or the struggle of dying. His experiments were made on the ventricles of the brain, the theca vertebralis, the pleura, and the pericardium.§

These membranes during life and health are transparent. At least M. Richerand tells us that on removing a portion of the

* Wm. Harvey, *De circulat. sanguin, ad* J. Riolan. p. 258. Glasgov. 1751. 12mo.; and especially his *Exerc. de gener. Animalium.* p. 263. Lond. 1651. 4to.

† See Theod. G. Aug. Roose, *Uber das Ersticken neugebohrner Kinder.* in his *Physiologisch. Untersuchungen.* Brunsw. 1796. 8vo. J. D. Herholdt, *De vita imprimis fœtus humani, ejusque morte sub partu.* Havn. 1802. 8vo.

‡ Consult, for example, Petr. J. Daoustenc, *De Respiratione.* Lugd. 1743. 4to. p. 54 sq. Rob. Whytt, *on the Vital and other involuntary motions of animals.* p. 222. Edinb. 1751. 8vo.

§ *The Morbid Anatomy of the Brain in Mania, Hydrophobia, &c.*

thorax when cutting away a cancer, he saw the heart through the pericardium.*

(B) Although each lower rib must execute a greater extent of motion from being longer than the one above, yet the first is asserted by M. Majendie to be absolutely more moveable than the second, the second than the third, &c.: and this because the first has but one articular surface, is articulated with but one vertebra, and possesses neither internal nor costo-transverse ligament, and has the posterior ligament horizontal, and because slight shades of difference exist in the disposition of the ligaments of the six other ribs.†

(C) To Dr. Carson we are indebted for the best account of the mechanical part of respiration.

The substance of the lungs is highly elastic, and constantly kept in a forced state of distention after birth by the pressure of the atmosphere. This is evident, as upon puncturing the walls of the thorax, the lungs instantly collapse,—a circumstance arising from the atmospheric pressure on the one hand becoming counterbalanced on the other, so that their elasticity, experiencing no opposition, becomes effective. During inspiration, the intercostal muscles raise and draw out the ribs, and the diaphragm descends: the enlargement of the thoracic cavity is instantly followed of necessity by the greater distention of the substance of the lungs from the diminished resistance to the atmosphere gravitating in the bronchiæ. The diaphragm and intercostal muscles ceasing to act, the substance of the lungs exerts its elasticity with effect, recovers its former dimensions, and drives out the additional volume of air just admitted, and the passive diaphragm and intercostal muscles follow the shrinking substance of the lungs, offering, from their relaxation, no resistance to the atmosphere pressing on the surface of the chest and abdomen. Thus expiration is produced. The muscular

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* *Journal de Médecine.* 1818.

† *Precis Elémentaire.* Tome ii. p. 270.

power of the diaphragm and intercostal muscles is far greater than the elastic power of the lungs, and therefore, when exerted, overcomes it, producing inspiration: but, ceasing to be exerted, the elastic power gains efficiency, and produces expiration. "The contractile power of the diaphragm (*and intercostal muscles*) in conformity with the laws of muscular motion, is irregular, remitting and sometimes altogether quiescent. The elasticity of the lungs, on the other hand, is equal and constant. The superior energy of the former is balanced by the permanency of the latter. By the advantage which the inferior power, from the uniformity of its operations, is enabled to take of the remissions of its more powerful antagonist, the ground which had been lost is recovered, and the contest prolonged; that contest in which victory declaring on one side or the other is the instant death of the fabric." *

In the common account of respiration, the elasticity of the lungs is unnoticed, and expiration is ascribed to the contractions of the abdominal muscles. Now in the first place, the elasticity of the lungs is of itself sufficient for the purpose; and in the second, there is no proof of the agency of these muscles in expiration. It proceeds equally well in cases of inanition, when their contraction would rather enlarge than diminish the abdominal cavity, and in experiments when they are entirely removed from animals.

The beautiful contrivance in the shape of the thorax deserves attention: by its being conical, every degree of motion in the diaphragm produces a greater effect on the capacity of the chest than could occur were it of any other shape.

The vacuum constantly threatening in the chest, either from the shrinking of the lungs or the contraction of the inspiratory muscles, and I may add from the expulsion of blood from the ventricles of the heart, will evidently be prevented, not only by the falling of the ribs and the ascent of the diaphragm in the

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* L. c. p. 223.

former case, and ingress of additional air into the bronchiæ in the latter, but also by the flow of venous blood into the auricles: for the venous blood, being subject to the full atmospheric pressure without the chest, will necessarily be driven into the chest to prevent a vacuum; the arterial blood is under the same circumstances, but the propelling force of the ventricles prevents its retrogression. The atmospheric pressure on the blood-vessels creates a necessity for greater strength in the ventricles, as it impedes the progress of blood from the heart, but it also facilitates the return. Thus the smaller pressure on the heart acts, by the intervention of the blood, as an antagonist to its contracting fibres, assisting to dilate them when they become relaxed.

By the tendency to a vacuum in the cavity of the thorax, what effect the heart loses by atmospheric resistance without the chest is exactly compensated within, and thus on the whole the heart neither gains nor loses by all the various directions of atmospheric pressure.

In the fœtus the case is precisely the same, although Dr. Carson has imagined it different, and thought it necessary to frame a little hypothesis to reconcile circumstances. The fœtal lungs, experiencing no atmospheric pressure, are contracted to the utmost, and the diaphragm suffering no stimulus from the will on account of uneasy sensation arising from want of breath, is completely relaxed and forced upwards, to remove the vacuum, and the venous blood without the thorax must, for the same reason, be drawn forcibly into the right auricle, preventing the vacuum which the shrunk state of the lungs, and the discharges of blood from the left ventricle, tend to produce.

The cause of the first inspiration appears to be the novel impression of cool air upon the surface, for if at any time we are suddenly exposed to a cold wind or plunge into cold water, the diaphragm and intercostal muscles instantly contract and a quick inspiration takes place. The blood rushes into the expanded lungs, and being afterwards obstructed when the inspiratory muscles cease to act, and the elastic lungs shrink, gives rise to an uneasy sensation, which is instinctively removed by another inspiration, and thus respiration afterwards continues through life. The fact of respiration commencing before the chord is tied, shows that neither the congestion in the aorta, nor the deficiency of chemical changes, is the cause of the first inspiration.

The elasticity of the lungs is not sufficiently great to expel the whole of their air in expiration, whence they remain constantly in a certain degree of distention, and the course of the blood through them is never completely obstructed by expiration.

(D) It is now ascertained, that no oxygen is absorbed in ordinary respiration, but that what disappears goes entirely to unite with the carbon of the blood and produce carbonic acid, the latter being exactly equal in bulk to the oxygen that disappears,—about 27½ cubic inches per minute, or 39,534 in 24 hours, according to the experiments of Messrs. Allen and Pepys,—a quantity containing about 11 oz. troy of solid carbon, and perhaps about double the average result of most other experiments. Mr. Ellis* contends that the carbon escapes from the vessels and unites with the oxygen externally, and Dr. Prout thinks this opinion corroborated by a fact stated by Orfila,†—that when phosphorus dissolved in oil is injected into the blood-vessels, vapours of phosphorous acid stream from the mouth and nostrils, which would hardly have occurred if the acid had been formed in the vessels, as it would probably have remained in solution in the blood, not being volatile :—the phosphorus was probably excreted from the vessels in minute subdivision, and united with the oxygen of the atmosphere upon coming in contact with it, producing phosphorous acid; and the same may be imagined respecting the carbonic.‡ Allen and Pepys observed that if respiration of the same air was breathed repeatedly, some oxygen was absorbed; and that if nearly pure oxygen was

* *On Respiration.* † *Toxicologie Generale.*

‡ Thomson's *Annals of Philosophy.* 1819.

employed in the case of guinea-pigs, pure carbonic acid was produced and a portion of the oxygen replaced by nitrogen, this portion, however, decreasing as the experiment proceeded. The use of the nitrogen that we respire is unknown.

The universality of respiration or something analogous among living beings,* and all the circumstances attending its performance, render it probable, as my friend Dr. Prout justly remarks, that it does something more than discharge a little superfluous carbon.† He considers galvanism as an instrument extensively used by the vital principle, and since galvanism must be produced by the combination of carbon with oxygen, as it is in the battery by the union of the metal and oxygen, one great additional purpose of respiration becomes highly probable.

Dr. Prout and Dr. Fyfe have found the quantity of carbonic acid gas experience uniform variations. It is diminished by mercury, nitric acid, vegetable diet, tea, substances containing alcohol, depressing passions, and fatigue, and undergoes an increase from day-break till noon, and a decrease from noon till sun-set, remaining at the minimum till day-break.‡ In the experiments of Allen and Pepys, the formation of carbonic acid gas slackened when the guinea-pigs fell asleep.

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* *Fish* and *crustacea* purify their blood by the air contained in the water that they draw over their gills, and the former not only discharge carbon but absorb oxygen and azote (*Mem. d'Arcueil.* ii. 55.) : the *syren lacertina* and *proteus anguina* have both gills and lungs : *insects* have no lungs but openings on the surface of the body leading to air-vessels that are distributed in the interior. All the experiments of naturalists made it appear that no animal could live without air, but M. Biot has lately asserted that what his countrymen call *blaps* and *tenebrions* remain in as good a vacuum as can be formed for any length of time without apparent inconvenience. Animals found in the secretions and blood vessels of others must live without atmospheric air. Vegetables occasion the same changes in the air as animals.—Ellis, *Further inquiries into the changes induced in atmospheric air, &c.*

† Thomson's *Annals of Philosophy.* 1814.

‡ l. c. *Dissert. Inaugur. &c.* Edinb. 1814. The smallest quantity yet observed was in a diabetic patient of mine, taking very large doses of opium and nux vomica.

The average number of respirations in a minute in adults is probably twenty.

The common quantity of air taken in at each inspiration is 16.5 cubic inches, and the quantity remaining after death in the lungs of a stout adult man, about 100 cubic inches, according to Allen and Pepys.

The quantity of aqueous vapour emitted by the lungs in expiration may be about 20 oz. in 24 hours.*

Camphor, phosphorus, ether, diluted alcohol, gases, and various odorous substances, when introduced into the system escape in some measure by the lungs.

(E) The experiment consisted in laying the lungs completely bare, and supporting life by carrying on respiration artificially. Hooke varied it by pricking the surface of the lungs and forcing a continued stream of air through them. The following are the words of Harvey: "It would appear that the use of expiration is to purify and ventilate the blood, by separating from it these noxious and fuliginous vapours."

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* Thomson, *System of Chemistry*. vol. iv.

SECT. IX.

OF THE VOICE AND SPEECH.

152. We have described the chief use of respiration. We shall hereafter mention how far it contributes to the conversion of the chyle into blood, and to the support of almost the whole class of natural functions. Its other uses are at present to be considered.

And first, respecting the *voice.** This takes place after birth, and proceeds from the lungs, as was observed long ago by Aristotle, who called those animals only vocal, which breathed by means of lungs. The voice is, properly speaking, a sound, formed, by means of expiration, in the *larynx*, which is a most beautifully constructed organ, fixed upon the top of the windpipe, like a capital upon a pillar.†

153. The larynx is composed of various cartilages, which being united together in the form, as it were, of a little box,‡ and supplied with a considerable and wonderful apparatus of muscles,§ may be moved altogether, or separately, according to the variations of the voice.

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* Th. Young, *Philos. Trans.* 1800. P. 1.

† Jan. Marg. Busch, *De Mechanismo organi Vocis hujusque functione.* Groning. 1770. 4to.

‡ Soemmerring, *Icones organorum Gustus et Vocis.* Francof. 1808. fol.

§ B. S. Albinus, *Tab. Muscul.* Tab. X. fig. 1—15. Tab. XI. fig. 45—48. Tab. XII. fig. 1—7.

154. The part of the larynx most concerned in producing the voice, is the *glottis,* or narrow opening of the windpipe, having the epiglottis suspended, and, in a manner, fixed upon it. It is clearly ascertained, that the air, expired from the lungs, and striking properly upon the margins of the glottis, becomes sonorous.

155. But it has been disputed what changes the glottis undergoes in modulating the voice: whether it is alternately widened and constricted, as Galen and Dodart supposed, or whether, according to Ferrein, the variations of voice are effected rather by the tension and relaxation of its ligaments.

The latter, consistently with his opinion, compared the larynx to a violin; the former, more consistently with nature, to a flute.*

Every thing considered, we must conclude that the glottis, when sounding, experiences both kinds of changes; since the grave and acute modulation of the voice must depend very much upon the alterations produced in the glottis by the ligaments, especially the *inferior* thyreo-arytenoids—the *vocal chords* of Ferrein, and by the corresponding modification of the *sinuses* or *ventricles of the larynx.*†

156. That every degree of motion in the glottis is directed by the numerous muscles of the larynx, is

* Kratzenstein viewed the glottis and larynx as a kind of drum, with its head bisected. *Tentamen de natura et charactere Sonorum Litterarum Vocalium.* Petrop. 1781. 4to. I would, in some sense, compare it to an Eolian harp, particularly one of the description found by Labillardiére in Amboyna. *Voyage à la Recherche de la Pérouse.* T. i. p. 326.

† See some experiments made at Gottingen with the view of settling this controversy, in J. G. Runge's Dissertation *De Voce ejusque Organis.* L. B. 1753. 4to. Also consult Jos. Ballanti, *Commentar. Instituti Bonon.* T. v. and Vicq.-d'Azyr, *Mém. de l'Acad. des Sc. de Paris.* 1779.

proved by the beautiful experiment of tying or dividing the recurrent nerves, or par vagum,* and thus weakening or destroying the voice of the animal. (A)

157. Man and singing birds have the power of *whistling*. In the latter, it is accomplished by a larynx placed at each extremity of the wind-pipe and divided into two portions. The former, though possessing a single and undivided larynx, has only learned, I imagine, to imitate birds by the coarctation of his lips.†

158. *Singing*, which is compounded of speech and an harmonic modulation of the voice, I conceive to be peculiar to man and the chief prerogative of his vocal organs. The power of whistling is innate in birds; many of them may easily be taught to pronounce words, and instances have been known of this even in dogs. But it is recorded, that genuine singing has once or twice only, and then indeed but indifferently and with the utmost difficulty, being taught to parrots; while, on the other hand, scarcely a barbarous nation exists, in which singing is not common.‡

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* Respecting this celebrated experiment, anciently made by Galen, consult among others W. Courten, *Philos. Trans.* N. 335. Morgagni, *Ep. Anatom.* xii. No. 20. P. P. Molinelli, *Comment. Instituti Bonon.* Tom. iii. J. Haighton, *Memoirs of the Medical Society of London.* T. iii.

† The larynx, even among the most ferocious people, is capable of imitating the sounds of animals. Consult v. c. Nic. Witsen, *Noord en oost—Tartarye*, ed. 2. Amst. 1705. vol. 1. p. 165, respecting the southern inhabitants of New Guinea, called *Papus*. And J. Adair, *History of the American Indians.* p. 309, respecting the Choktah tribe of North America.

‡ I have in my hands the testimony of most respectable travellers, in regard, for instance, to the inhabitants of Ethiopia, Greenland, Canada, California, Kamtschatka, &c. and therefore wonder at the assertion of Rousseau,—that singing is not natural to man. *Dictionn. de Musique.* T. i. p. 170. Genev. 1781. 12mo.

159. *Speech* is a peculiar modification of the voice, adjusted to the formation of the sounds of letters by the expiration of air through the mouth or nostrils, and in a great measure by the assistance of the tongue, applied and struck against the neighbouring parts, the palate and teeth in particular, and by the diversified action of the lips.* (B)

The difference between voice and speech is therefore evident. The former is produced in the larynx; the latter by the singular mechanism of the organs above described.

Voice is common to both brutes and man, even immediately after birth, nor is entirely absent in those wretched infants who are born deaf. But speech follows only the culture and employment of reason, and is consequently, like it, the privilege of man in distinction to the rest of animal nature. For brutes, natural instinct is sufficient: but man, destitute of this and other means of supporting his existence independently, enjoys the prerogative of reason and language; and following, by their means, his social destination, is enabled to form, as it were, and manifest his ideas, and to communicate his wants to others, by the organs of speech.

160. The mechanism † of speech and articulation is

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* See Rich. Payne Knight, *Analytical Essay on the Greek Alphabet.* Lond. 1791. 4to. p. 3.

† Consult F. Mercur. ab Helmont, *Alphabeti vere naturalis Hebraici Delineatio.* Sulzbac. 1657. 12mo.

Joach. Jungius, *Doxoscopiæ Physicæ Minores* (1662.) 4to. Append. Section. i. P. ii. fol. Gg. ii. 3.

J. Wallis, *Grammatica Linguæ Anglicanæ, cui præfigitur de loquela s.*

so intricate and so little understood, that even the division of letters and their distribution into classes * is attended with much difficulty.

The division, however, of Ammann,† into vowels, semi-vowels, and consonants, is very natural:

I. He divides the vowels ‡ into *simple*—*a, e, i, y, o, u*, and mixed—*ä, ö, ü*.

These are formed by merely the VOICE.

The semi-vowels and consonants are articulated by the mechanism of SPEECH.

II. The semi-vowels are *nasal*—*m, n, ng* (*n* before *g*, which is nearly related to it), that is, the labio-nasal *m*, the dente-nasal *n*, and the gutture-nasal *ng;* or *oral* (lingual)—*r, l*, that is, *r* with a vibration of the tongue, or *l* with the tongue less moved.

III. The consonants are distinguished into *hissing* (pronounced in succession)—*h, g, ch, s, sch, f, v, ph*, that is *h*,—formed in the throat, as it were a mere aspiration; *g* and *ch*—true consonants; *s, sch*,—produced between the teeth; *f, v, ph*,—formed by the application of the lower lip to the upper front teeth: and *explosive* (which are, in a manner, at once exploded, by an expiration, for some time suppressed or inter-

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sonorum omnium loquelarium formatione tract. grammatico-physicus. Ed. 6. Lond. 1765. 8vo.

Gottl. Conr. Chr. Storr, *De Formatione Loquelæ.* Tubing. 1781. 4to.

* K. G. Anton, *Uber Sprache in Rücksicht auf Geschichte der Menschheit.* Görlitz. 1799. 8vo.

Er. Darwin, *Temple of Nature. Addit. Notes*, p. 112.

† His *Surdus Loquens.* Amst. 1692. 8vo. With the *Dissert. de Loquela. Ib.* 1700.

‡ Respecting their formation, consult Chr. Theoph. Kratzenstein, *Tentamen*, recommended above.

rupted) that is, *k*, *q*,—formed in the throat; *d*, *t*,—about the teeth; *p*, *b*,—near the lips; and *double* (compound)—*x*, *z*.

161. We must just mention certain other modifications of the human voice, of which some, as hiccup and cough, belong more properly to pathology than to physiology, but are very common in the most healthy persons; and others, as weeping and laughing, appear peculiar to the human race.

162. Many of these are so closely allied, as frequently to be converted into each other; most also are variously modified.

In *laughter* there is a succession of short and abrupt expirations.*

Coughing is a quick, violent, and sonorous expiration, following a deep inspiration.†

Sneezing, generally the consequence of an irritation of the mucous membrane of the nostrils, is a violent and almost convulsive expiration, preceded by a short and violent inspiration.‡

Hiccup, on the contrary, is a sonorous, very short, and almost convulsive, inspiration, excited by an unusual irritation of the cardia.§

In *weeping* there are deep inspirations, quickly alternating with long and occasionally interrupted expirations.||

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* Fr. Lupichius, *De Risu*. Basil. 1738. 4to. *Traité des Causes physiques et morales du rire*. Amst. 1788. 8vo.

† J. Melch. Fr. Albrecht, (Præs. Hallero) *Experimenta in vivis animalibus circa tussis organa exploranda instituta*. Gotting. 1751. 4to.

‡ Marc. Beat. L. J. Porta, *De Sternutatione*. Basil. 1755. 4to.

§ C. J. Sig. Thiel, *De Singultu*. Gotting. 1761. 4to.

|| J. F. Schreiber, *De Fletu*. L. B. 1728. 4to.

Sighing is a long and deep inspiration, and the subsequent expiration is sometimes accompanied by *groaning.**

Nearest in relation to sighing is *gaping*,† which is produced by a full, slow, and long, inspiration, followed by a similar expiration, the jaws at the same time being drawn asunder, so that the air rushes into the open fauces and the Eustachian tubes. It occurs from the blood passing through the lungs too slowly; v. c. when the pressure of the air is diminished, as upon very high mountains. A peculiar feature of gaping is the propensity it excites in others to gape likewise; arising, no doubt, from the recollection of the pleasure it produced. (C)

NOTES.

(A) M. Le Gallois ascertained that the division of the recurrent nerves frequently proves even fatal to animals. This effect, however, varies with the species and age. The danger diminishes as the animal is older; and, after a certain age, little inconvenience follows, because the (anterior part of the ?) opening of the glottis is larger proportionally to the capacity of the lungs not merely in some species than others, but in old than in young animals.‡

The inferior ligaments of the glottis are the chief seat of the

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* Dav. C. Em. Berdot, *De Suspirio.* Basil. 1756. 4to.

† Just. Godofr. Günz, (Præside Walthero) *De Oscitatione.* Lips. 1738. 4to.

‡ *Expériences sur le Principe de la Vie.*

voice, for in blowing into the trachea and larynx of an animal a slight sound only is heard, unless you approximate the arytenoid cartilages to each other, when a sound somewhat analogous to the voice of the animal will be produced, and more acute in proportion to their approximation, and it will be seen, at the same time, that the sound is caused chiefly by the vibrations of the inferior ligaments of the glottis. Again, an opening below the inferior ligaments destroys the voice, while one above it, even through the epiglottis, superior ligaments, and arytenoid cartilages, has no such effect. In grave tones, the whole length of the inferior ligaments may be seen in a dog to vibrate; in more acute, the posterior part only; and in very acute, merely the arytenoid extremity, the opening of the glottis being of course lessened in the same proportion. These circumstances depend upon the thyro-arytenoid muscles, which run on each side from the arytenoid to the thyroid cartilage and form the lips of the glottis (and indeed also the superior ligaments,) covered by an aponeurosis, and this again by the mucous membrane. In proportion as these contract, they become shorter and more tense, and lessen the mouth of the glottis; but the complete closure of the glottis at the back part is effected by the arytenoid muscle, which connects the two arytenoid cartilages. As all these are voluntary muscles, the division of their nerves destroys the voice. The division of the recurrents, which supply the thyro-arytenoid muscles, is sufficient for this purpose; but, in some instances, a sound still remains similar to what may be produced after death by blowing through the larynx after approximating the arytenoid cartilages, and must be owing to the action of the arytenoid muscle, which is supplied not by the recurrent but by the superior laryngeal nerves. As this muscle is the chief means of contracting the posterior part of the glottis and producing the most acute sounds, the division of the superior laryngeal nerves destroys almost all acute sounds and renders the voice grave. When the division of the recurrent nerves proves fatal, it does so by paralysing the muscles that dilate the glottis, for the arytenoid muscle that closes the back part of it, being supplied by the superior laryngeal, acts unopposed.

"It is therefore evident that the larynx represents a reed with two plates, the tones of which are acute in proportion as the plates are short, and grave in proportion as they are long. But although this analogy is just, we must not imagine that there is a perfect identity. In fact, common reeds are composed of rectangular plates fixed on one side and free on the three others, while the vibrating plates of the larynx, which are also nearly rectangular, are fixed on three sides and free on one only. Besides, the tones of common reeds are made to ascend or descend by varying their length; but the plates of the larynx vary only in breadth. Lastly, the moveable plates of the reeds of musical instruments cannot, like the ligaments of the glottis, change every moment in thickness and elasticity." The changes in both the length and breadth of the trachea and of the cavity between the glottis and the lips, and in the state of the epiglottis and the ventricles of the larynx, must affect the *voice*.*

(B) I am indebted to the tremendously powerful Conyers Middleton for the knowledge of two cases of distinct articulation with at least but little tongue.† In his exposure of the difference between the *pious* deceptions of weak and wicked Christians during the first centuries and the sublime miracles of Christ and his apostles, he notices a pretty tale of an Arian prince cutting out the tongues of some of the orthodox party and these being as able to talk as before; nay one (O hominum impudentia!) who had been dumb from his birth, gained the faculty of speech by losing his tongue. Granting the fact, and even that the tongues were completely extirpated, he refers, for the purpose of proving there was no miracle in the case, to two

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* F. Majendie, *Précis Elémentaire de Physiologie.* T. i. p. 216 sq.

† *An Enquiry into the miraculous Powers, &c.* Miscellaneous Works. vol. i. p. 148.

relations of similar instances by medical men in the *Mémoires de l'Academie des Sciences,* p. 6. 1718. Professor Thomson found the speech little impaired after the bullets had carried away more or less of the tongue.* Louis, Richter, Huxham, Bartholin, Tulpius, it seems, mention similar cases. An instance of good articulation after the loss of the apex and body of the tongue quite down to the os hyoides occurred in this country.†

* *Report of Observations made in the British Hospitals in Belgium, after the Battle of Waterloo; with some Remarks on Amputation.*

† *Phil. Trans.* 1746.

SECT. X.

OF ANIMAL HEAT.

163. MAN, the mammalia, and birds, are distinguished by the natural temperature* of their bodies greatly exceeding that of the medium in which they are accustomed to exist. Man is again distinguished from these classes of animals by possessing a much lower temperature than they; so that in this climate it is about 96° of Fahr. while in them, and especially in birds, it is considerably higher.†

164. This natural temperature in man, is so constant, equable,‡ and perpetual, that, excepting slight differences from variety of constitution, it varies but little even in the coldest climate and under the torrid zone. For the opinion of Boerhaave,—that man cannot live in a temperature exceeding his own, has been refuted, since the admirable observations§ of H. Ellis,

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* W. B. Johnson, *History of Animal Chemistry.* Vol. iii. p. 79.

† The torpid state of some animals, during winter, is of course an exception to this. During it most of the functions cease or languish considerably, and the animal heat is reduced nearly to coolness. This well-known circumstance prevents me from acceding to the opinion of the very acute J. Hunter,—that the animals which we call warm blooded, should rather be called animals of a permanent heat under all temperatures. *On the Blood.* p. 15.

‡ J. B. Van Mons, *Journal de Physique.* T. lxviii. 1809. p. 121.

§ *Philos. Trans.* vol. i. P. ii. 1758. Arn. Dantze had previously made the observation in regard to brutes. *Exper. calorem animalem spectantia.* Lugd. Bat. 1754. 4to. Also Benj. Franklin, *Experiments and Observations on Electricity.* Lond. 1769. 4to. p. 365.

the celebrated traveller and formerly the captain of the George, by the remarkable experiments* of many excellent physiologists.† This striking prerogative of man is evinced by his being restricted to no climate, but inhabiting every part of the earth from Hudson's bay, where Mercury freezes, and from Nova Zembla, to the scorching shore of Senegal.

165. The explanation of this circumstance is equally simple and natural, and founded on the doctrine which makes the lungs the grand receivers or focus, and the decomposition of the oxygenised portion of the air (148) the source or fomites, of our heat.

166. For, as the oxygenous part of the inspired air is decomposed in the air-cells of the lungs, in such a way that its base, which by its union with *latent* caloric was before aëriform, now separates from this caloric, it would appear that, by this decomposition, one portion of the caloric is rendered sensible in the bronchiæ, while the other enters in a latent form into the blood, circulating in the innumerable and delicate net-works of the pulmonary vessels.‡

167. When the oxygenised blood thus charged with latent heat circulates through the aortic system, it acquires carbon in the small vessels and sets free much

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* Duhamel and Tillet, *Mém. de l'Acad. des Scienc. de Paris.* 1704. Blagden and Dobson, *Philos. Trans.* 1765.

† The heat of the weather, even in Europe, occasionally exceeds our natural temperature. This was the case on the third of Aug. 1783, at noon, when I was on the Lucerne Alps, in company with the excellent Schnyder of Wartensee. The Thermometer in the shade stood above 100°. Fahr. and when applied to the body, invariably sunk to near 97°.

‡ See Lichtenberg's animadversions upon this part of Crawford's Theory, in his notes to Erxleben's *Anfangsgr. der Naturlehre.* p. 447. ed. vi.

of the latent heat which it had received: in this way is our animal heat principally produced.*

168. Its production and regulation, however, appear much influenced by the *secretion* of fluids from the blood, both those which are liquid and destined to solidify by assimilation and nutrition, and those which are permanently elastic.

169. Since those changes are effected by the energy of the *vital powers*, the great influence of these upon our temperature must be easily perceived.†

170. Many arguments render it probable, that the action of the minute vessels, and the conversion of oxygenised into carbonised blood, are dependent upon the varied excitement or depression of the vital principle.

For the remarkable phenomena of the stability of our temperature,‡ (proved by the thermometer, and not by the sense of touch, which may be fallacious)—that

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* Hence the constant coldness of those wretched beings who labour under the *blue disease*, which arises from a mal-conformation of the heart. Sometimes the septa of the heart are imperfect, sometimes the aorta arises with the pulmonary artery from the right ventricle, as in the tortoise. In such instances, the chemical changes can take place in the lungs but imperfectly. Among innumerable instances of this lamentable disease, suffice it to quote J. Abernethy, *Surgical and Physiological Essays.* P. ii. p. 158, and Fr. Tiedemann, *Zoologie.* T. i. p. 177.

† I have formerly treated of the influence of the nervous system upon animal heat, in my *Specimen Physiologiæ Comparatæ inter animantia calidi & frigidi sanguinis.* p. 23.

See the same confirmed by many arguments in Magn. Ström's *Theoria inflammationis doctrinæ de calore Animali superstructa.* Havn. 1795. 8vo. p. 30 sq. and by the much lamented Roose, *Journal der Erfindungen*, &c. T. v. p. 17.

Consult also Dupuytren, *Analyse des Travaux de l'Institut.* 1807. p. 16.

‡ See Crawford, *Philos. Trans.* vol. lxxi. p. ii.

it is scarcely increased by the heat of summer, or diminished by the cold of winter, but found sometimes even to increase on immersion in cold water,* demonstrate that the action of the minute vessels varies according to the temperature of the medium in which we are placed: so that, when exposed to a low temperature (by which their tone is probably augmented) more oxygen is exchanged for carbon and more heat evolved, while in a high and debilitating temperature this exchange is diminished and less heat evolved. †

171. The *corium*, which covers the body, and the internal surface of the *alimentary canal*, eminently contribute, if we are not much mistaken, to regulate our temperature. For both these organs are supplied with an immense number of blood-vessels, being analogous in this respect to the lungs, and are so intimately connected with the lungs by means of sympathy,‡ as in some degree to perform a part, and occasionally the whole, of some of their functions in their room. This is exemplified in adults labouring under nearly total consumption, or other violent affections, of the lungs, and nevertheless, existing for a length of time almost without respiration.§

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* G. Pickel, *Experimenta Physico-Medica de Electricitate et Calore animali.* Wirceb. 1788. 8vo. p. 91 sq.

† C. Ferd. Becker, *De Effectibus caloris et frigoris externi in c. h.* Gott. 1802. 4to.; and Wm. Fr. Baur, *On the same subject.* IB. EOD. (BOTH HONOURED WITH THE ROYAL PRIZE.) Mich. Skjelderup, *Dissert. sistens vim frigoris incitantem.* Hafn. 1803. 8vo.

‡ J. Chr. Fr. Goeschen, (Præs. Ph. Fr. Meckel) *Pulmonum cum Cute commercium.* Hal. 1789. 8vo. But especially J. D. Brandis, *Pathologie.* Hamb. 1808. p. 316 sq.

§ Consult, for instance, Tacconi, *Comment. Instit. Bononiens.* Vol. vi. p. 74.

172. This opinion respecting the action of the *cutaneous* vessels in exciting, moderating, or almost extinguishing, our heat, receives much support from the physiological and pathological facts of *some parts* being frequently of a higher or lower temperature than the rest of the system.

Thus we must attribute the coldness of the dog's nose to the specific action of its own vessels being modified differently from that of the rest; so on the other hand, the burning sometimes of the cheeks and sometimes of the palms of the hands in hectic fever, to the locally increased action of the vessels; besides other phenomena of the same description, v. c. the heat of the genitals during the venereal œstrum, and the obstinate coldness of the feet in certain diseases.

173. The *alimentary canal* is the only internal part, besides the lungs, exposed to the contact of the atmosphere. There is scarcely occasion to prove that it is so exposed, and that we swallow a considerable quantity of air.

The air, when swallowed, is decomposed in the stomach and intestines, so that, during health, it soon loses its elastic form: not, however, when the capillaries of the canal are debilitated, nor when it exists in too great quantity.

The immense congeries of blood-vessels in the intestines on their internal surface which is usually thought equal to the external surface of the body, agrees very well with this idea.

NOTE.

No phenomenon in living bodies is more remarkable than their peculiar temperature, and no one was of more difficult explanation before the progress of modern chemistry.

If two different bodies are placed in a temperature higher or lower than their own for a certain length of time, they will, at the end of the period, be found not of the same, but of different, temperatures. That which has the higher temperature, is said to have a smaller capacity for caloric; that which has the lower, a greater capacity. To raise the former to a given temperature, therefore, requires less heat than to raise the latter to the same degree.

The temperature of solids is more easily affected by a given quantity of heat, than that of fluids, and the temperature of fluids than that of aëriform bodies: or, in other words, solids have a smaller capacity for caloric, than fluids, and fluids than aëriform bodies. If, therefore, a solid becomes fluid, or a fluid aëriform, it absorbs a great quantity of heat, though its temperature remain precisely the same. And the converse holds equally good,—if an aëriform substance becomes liquid, or a liquid solid, the heat which it before contained is now (from its diminished capacity) much more than sufficient for the temperature which before existed, and the temperature of the body accordingly rises.

In respiration, the dark blood of the pulmonary artery parts with a portion of its carbon and acquires a florid hue. This carbon unites with the oxygen of the inspired air, and forms carbonic acid that is expired with the other constituent of the atmosphere,—nitrogen or azote, which appears to have experienced no change from inspiration.

Dr. Crawford rendered it probable, by his experiments, that the arterial blood has a larger capacity for caloric than the venous, and common air than carbonic acid gas. When, therefore, the carbon of the venous blood unites with the oxygen of the air and forms carbonic acid, the smaller capacity of this than of common air for caloric, must cause an increase of temperature, but the blood, having changed from venous to arterial, has acquired a greater capacity than before and absorbs the heat given out by the carbonic acid. The blood, of course, does not become warmer, because the heat is not more than sufficient to render its temperature equal to what it was previously; and indeed it is not quite sufficient for this, since the arterial blood of the pulmonary veins is generally two degrees lower than that of the pulmonary artery.

The body in this way acquires a fund of heat, and yet the lungs, in which it is acquired, do not experience any elevation of temperature.

The arterial blood, charged with much heat which is not sensible, as it circulates through the small vessels, becomes venous,—acquires a dark hue, and its capacity for heat is diminished; consequently its temperature rises,—the heat which was previously latent, is, from the decrease of capacity, sufficient to raise its temperature, and is evolved. In this mode, the loss of heat which occurs from the inferior temperature in which we live, is compensated. The fresh supply is taken in at the lungs, and brought into use in the minute vessels.

Of late, this theory has fallen into discredit.

All experiments upon the capacities of bodies for heat are very delicate and liable to error; and the conclusions of Crawford on this point have been denied by MM. Delaroche and Berard, with respect to the gases, and by Dr. Davy, with respect to arterial and venous blood.*

Mr. Brodie cut off the communication between the brain and lungs of animals, and continued respiration artificially.† The usual chemical changes continued in the lungs upon the blood, nevertheless the temperature of the animals diminished, and even more rapidly than if the respiration had not been continued, owing,

* *Philos. Trans.* 1814.

† *Philos. Trans.* 1812.

he says, to the succession of cool air sent into the lungs. He therefore concludes, that animal heat depends much more upon the nervous energy than upon the chemical changes of the blood. But Le Gallois asserts, that under artificial respiration the temperature falls, even if every part remain uninjured.* Dr. Crawford himself states that the chemical process of respiration may, in certain cases, be the means of cooling the body. If the pulmonary exhalation is in very great abundance, it will carry off so much of the heat given out during the change of the oxygen into carbonic acid, that there may not be sufficient to saturate the increased capacity of the arterial blood; this will therefore absorb heat from the system, as it passes along, till its temperature equals that of the other parts.†

Many circumstances, however, favour the doctrine of Crawford. In high temperatures we have less necessity for the evolution of heat by the chemical changes of the blood and air, whereas, in low temperatures, as more heat is required to sustain the natural degree of temperature, the chemical changes are more necessary. Accordingly, in very high temperatures, the arterial blood remains arterial,—is as florid in the veins as in the arteries, and the inspired air is less vitiated; in low temperatures, the venous blood is extremely dark, and the inspired air more vitiated.‡

The temperature is also regulated by the degree of perspiration, the momentum of the blood, &c. In proportion as more vapour transpires from the skin, will more heat be carried off, whence M. Delaroche heated animals at pleasure like inanimate matter by saturating their atmosphere with humidity, thus preventing cutaneous and pulmonary evaporation. And as the sum of the quantity and velocity of blood in any part is greater, the temperature of that part will be higher. Whether Crawford's theory be correct or not, the production of animal temperature must still be as evidently a chemical process as changes of temperature among inanimate bodies. But this does not prevent it

* *Sur le Principe de la vie.* † l. c. p. 388.

‡ Crawford *on Animal Heat.* p. 387 sq.

from strictly deserving the epithet vital, because it is regulated by the vital powers of the system, although through the instrumentality of chemical changes. If the high temperature of an inflamed part is owing to the increased momentum of the blood, yet this increased momentum is produced by the vital powers. As there is less vigour in old than in young persons, and in remote parts than in those which are near the centre of circulation, the momentum of the blood is less in the old than the young, and in parts remote than in parts near the heart; hence the temperature of the old falls short of the temperature of the young, and is stated to be in all persons lower in proportion to the distance of parts from the centre of circulation.*

All animate matter has a tendency to preserve a certain temperature. Even eggs are cooled and frozen with more difficulty than equal masses of inanimate matter, though, when once frozen and their life destroyed, they freeze readily.† Vegetables shew the same tendency by the greater difficulty with which the juices in their stems and branches are frozen than lifeless fluids, and by ice thawing when roots shoot into it.‡

* Dr. Davy, *Philos. Trans.* 1814.

† Hunter, *on the Blood, &c.* p. 79.

‡ *American Medical and Philosophical Register.* 1814. p. 19.

SECT. XI.

OF PERSPIRATION.

174. The functions of the skin, which affords a covering to the body, are so extremely various that they cannot all be easily described with advantage in one chapter, but each will be considered far more conveniently under that class of actions to which it belongs.

For, in the first place, the skin is the organ of touch, and will be examined in this view, under the head of animal functions.

It is an organ of inhalation, and in this point of view belongs to the absorbent system, to be spoken of among the natural functions.

It is likewise the organ of perspiration, and on this account related in many ways to the function of respiration, and may, we think, very properly follow it in this place,

175. The skin consists of three membranes—The *corium*, internal; the *cuticle*, external; and the *reticulum*, intermediate.

176. The *cuticle* or epidermis * forms the external covering of the body, is separable into lamellæ,† and exposed to the atmosphere, the contact of which can be borne by scarcely any other part, if you except the

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* Al. Monro (*Primus*), *Oratio de Cuticula Humana*. Opera. English edition. Edinb. 1781. 4to. p. 54. sq.

† Among others, consult J. Mitchell, *Philos. Trans.* Vol. xliii. p. 111.

enamel of the teeth. For this reason, the internal cavities and the canals which communicate with the surface for the purpose of admitting air, especially the respiratory passages and the whole of the alimentary canal, the tongue, the inside of the cheeks, the fauces, and the organ of smell, are covered by a fine epithelium, originating from the epidermis.*

177. The texture of the epidermis is extremely simple, destitute of vessels, nerves, and of true mucous web, and consequently but little organised; very peculiar, however,† remarkably strong, considering its pellucidity and delicacy, so that it resists for a great length of time maceration, suppuration, and other modes of

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* Abr. Kaau, *Perspiratio dicta* Hippocrati. p. 7.

Lieberkühn, *De fabrica Villor. Intestin. Tenuium.* p. 16.

Cruikshank, *Expts. on the Insensible Perspiration.* p. 5.

Rudolphi, *Reisebemerkungen.* T. i. p. 29. 140.

Jens. W. Neergaard, *Vergleichende Anat. der Verdauungswerkzeuge,* p. 21, & alibi.

† The very dense epidermis of some immense animals consists of vertical fibres which, in arrangement, somewhat resemble the structure of the Boletus igniarius. Its internal surface is porous and penetrated by the silky filaments of the subjacent corium. This is remarkably exemplified in a preparation now before me, taken from the skin of the balæna mysticete. The human cuticle, in certain diseased states, exhibits the same appearance as in the Englishman called the Porcupine Man, who laboured under a cuticular complaint which he transmitted to his children and grand-children. Vide W. G. Tilesius, *Beschreibung und Abbildung der beiden sogenannten Stachelschwein-Menschen* (Porcupine Men). Altenb. 1802. fol.

The innumerable polyedrical papillæ and horny warts which I witnessed upon every part of the skin of these brothers, excepting the head, the palms of the hands, and the soles of the feet, bore some resemblance to the skin of the elephant, especially about the vertex and forehead of the animal. (A)

Similar also are corns and the brawny cuticle of the feet in those who walk barefooted. Vide Carlisle on the Production and Nature of Corns, *Med. Facts and Observations.* Vol. vii. p. 29.

destruction, and reproduced more easily than any other of the similar parts.

178. It is completely sui generis, somewhat like a horny lamella, and adheres to the subjacent *corium* by the intervention of a mucus, and by numerous very delicate fibrils which penetrate the latter.*

The pores which Leuwenhoek imagined in it, do not exist; but it allows a very ready passage to caloric, carbon, hydrogen, and to matters immediately composed of these, v. c. oil.

179. The importance of the cuticle to organised systems, is demonstrated by its universality in the animal and vegetable kingdoms, and by its being distinctly observable in the embryo from the third month at latest after conception.

180. The inner part of the cuticle is lined by a fine mucous membrane, denominated from the opinion of its discoverer, *reticulum Malpighianum*, and by means of which chiefly the cuticle is united more firmly to the corium.†

Its nature is mucous, it is very soluble, and, being thicker in Ethiopians, may be completely separated in them from both the corium and cuticle, and made to appear as a true distinct membrane.‡ (B)

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* W. Hunter, *Med. Observations and Inquiries.* vol. ii. p. 52 sq. tab. i. fig. 1, 2. The conjecture of this eminent man,—that the fibrils excrete the perspirable matter, is, I think, improbable.

† Hence I have found the Epidermis of Albinos separate easily by the heat of the sun; whereas in negroes, it scarcely does so on the application of a blister. C. F. Mitchell, l. c. p. 108.

‡ B. S. Albinus, *De sede & causa coloris æthiopium et cæteror. hominum.* Lugd. Batav. 1737. 4to. fig. 1.

Sam. Th. Soemmerring, *Uber die körperl. Verschiedenh. des Negers vom Europäer.* Ed. 2. p. 46, sq.

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181. Our colour resides in it. In all persons the corium is white, and, in almost all, the cuticle white and semipellucid, though in Ethiopians it inclines to grey. But the mucous reticulum varies after birth, with age, mode of life, and especially with difference of climate.

Thus among the four varieties into which I would divide the human race, in the first, which may be termed Caucasian and embraces Europeans (except the Laplanders and the rest of the Finnish race), the western Asiatics, and the northern Africans, it is more or less *white*.

In the second or Mongolian, including the rest of the Asiatics (except the Malays of the peninsula beyond the Ganges), the Finnish races of the north of Europe, as the Laplanders, &c. and the tribes of Eskimaux diffused over the north of America, it is *yellow* or resembling box wood.

In the third—the Ethiopian, to which the remainder of the Africans * belong, it is of a *tawny* or *jet black*.

In the fourth or American, comprehending all the Americans excepting the Eskimaux, it is almost copper coloured,—of a dark *orange* or *ferruginous* hue.

In the fifth or Malaic, in which I include the inhabitants of all the islands in the Pacific Ocean, and of the Philippine and Sunda, and those of the peninsula of Malaya, it is more or less *tawny*,—between the hue of fresh mahogany and that of cloves or chesnuts.

Some even of the moderns have assigned many laminæ, and even different kinds of laminæ, to the reticulum; as Lieutaud, *Essais Anatomiques*. p. 103. ed. 1766. and Cruikshank, l. c. p. 43. 99.

Others make it organic. Consult, v. c. Mich. Skjelderup, l. c. p. 93.

* Jo. Nic. Pechlin, *De Habitu et Colore Æthiopum, qui vulgo et Nigritæ*. Kilon. 1677. 8vo. Camper's oration on the same subject will be found in his *Kleiner Schriften*, Vol. i. P. 1, p. 24—49.

All these shades of colour, as well as the other characteristics of nations and individuals, run so insensibly into one another that all division and classification of them must be more or less arbitrary.

182. The essential cause of the colour of the Malpighian mucus, is, if we mistake not, the proportion of carbon which is excreted together with hydrogen from the corium, and in dark nations, being very copious, is precipitated upon the mucus and combined with it.*

183. The corium, which is covered by the reticulum and epidermis, is a membrane, investing the whole body and defining its surface; tough; very extensible; of different degrees of thickness; every where closely united, and, as it were, interwoven, with the mucous tela, especially externally, but more loosely on its internal surface, in which, excepting in certain parts, we generally discover fat.

184. Besides nerves and absorbents, innumerable blood vessels, of which we shall speak hereafter, penetrate to its external surface, upon which they are shewn, by minute injection, to form very close and delicate net-works.

185. A vast number of sebaceous follicles also are dispersed throughout it, which diffuse over the skin an oil,† thin, limpid, and not easily drying,‡ altogether

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* I have given this opinion at some length in my work, *De Gen. Human. Varietate Nativa.* p. 122 sq. ed. 3. Some eminent chemists accord with me, among whom suffice it to mention the celebrated Davy, *Journals of the Royal Institution.* vol. ii. p. 30. " In the rete mucosum of the African, the carbon becomes the predominant principle; hence the blackness of the negro." W. B. Johnson, l. c. vol. ii. p. 229.

† Chr. Gottl. Ludwig, *De Humore cutem inungente.* Lips. 1748. 4to.

‡ Lyonet, *Lettre à M. Le Cat.* p. 12.

distinct from the common sweat, and from that which possesses an odor resembling the odor of goats and is peculiar to certain parts only.

186. Lastly, almost every part of the corium is beset with various kinds of hairs,* chiefly short and delicate, more or less downy, and found nearly every where but on the palpebræ, penis, the palms of the hand, and the soles of the feet. In some parts, they are long and destined for peculiar purposes; such are the capillamentum, the eyebrows, the eye-lashes, the vibrissæ, mustachios, beard, and the hair of the arm-pits and pudenda.

187. Man is, generally speaking, less hairy than most other mammalia. But in this respect nations differ. For, not to mention those nations who to this day carefully pluck out their beard or the hair of other parts, others appear naturally destitute of hair, v. c. the Tunguses and Burats; (C) on the contrary, creditable travellers assert that some inhabitants of the islands in the Pacific and Indian Ocean are remarkable hairy.†

188. Nor is there less variety in the length, flexibility, colour, and disposition to curl, both in each race of men enumerated above (181) and in individuals. V.c. The hair of the head in the Caucasian variety is rather dingy or of a nut brown, inclined on one hand to yellow and on the other to black; in the Mongolian and American, it is black, stiffer, straight, and more sparing; in the Malay, black, soft, curling, thick, and abundant; in the Ethiopians, black and woolly: In individuals, espe-

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* Jo. Ph. Withoff, *De pilo humano.* Duisb. 1750. 4to. Compare the *Commentar. Societ. Scient. Gotting.* Vol. ii.

Job. Baster, *Verhandel. der Maatsch. te Haarlem.* T. xiv. p. 382.

† *De Generis Human. Variet. Nativ.* p. 29.

cially of the Caucasian variety, there are great differences, and chiefly in connection with *temperament,* which is found intimately and invariably connected with the colour, abundance, disposition to curl, &c. of the hair;* and there also exists a remarkable correspondence between the colour of the hair and of the iris.

189. The direction of the hairs is peculiar in certain parts, v. c.—spiral on the summit of the head—diverging upwards on the pubes—on the exterior of the arm, as is commonly seen in some anthropomorphous apes, (v. c. in the satyrus and troglodytes) running in two opposite directions towards the elbow, i. e. downwards from the shoulder, upwards from the wrist; to say nothing of the eye-lashes and eye-brows.

190. The hairs originate from the inner surface of the corium, which abounds in fat. They adhere to it pretty firmly,† by a curious bulb, consisting of a double involucrum;‡—the exterior vascular and oval, the interior cylindrical, apparently continuous with the epidermis,§ and sheathing the elastic filaments of which the hair is composed, and which are generally from five to ten in each.

191. The hairs are almost incorruptible, and always anointed by an oily halitus. Of all parts they appear

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* Galen, *Ars Medicinalis.* p. 211—235. M. Ant. Ulm, *Uterus Muliebris.* p. 128, et alibi. Lavater, *Fragmente.* T. iv. p. 112, among many others.

† I suspect that the bulb is intended for support rather than for nourishment, from this circumstance,—that the locks of hairs sometimes found in meliccra and steatomata of the omentum and ovarium, some of which I have now before me, are usually destitute of bulbs, because they are not fixed, but lie naked in the honey-like fatty matter.

‡ Duverney, *Œuvres Anatomiques.* Vol. i. Tab. xvi. fig. 7, 9—14. Tab. xvij. fig. 3 sqq.

§ B. S. Albinus, *Annotat. Academ.* L. vj. Tab. iij. fig. 45.

most truly electrical. They are very easily nourished, and even reproduced, unless where the skin is diseased.

192. Besides the functions ascribed to the integuments in the former Section, must be enumerated their excretory power, by which foreign and injurious matters are eliminated from the mass of fluids.*

This is exemplified in the miasmata of exanthematic diseases, in the smell of the skin after eating garlic, musk, &c. and in sweating and similar phenomena.

193. What is most worthy our attention, is the transpiration of an aëriform fluid, denominated, after the very acute philosopher who first applied himself professedly to investigate its importance, the *perspirabile Sanctorianum,*† and similar to what is expired from the lungs.‡ It likewise is composed of various proportions of carbon,§ nitrogen, and hydrogen,|| precipitates lime from solution, and is unfit to support either flame or respiration.

194. The *sweat,* which seldom occurs spontaneously during health and rest, unless in a high temperature, appears to arise from the perspirable matter of Sanctorius being too much increased in quantity by the excited action of the cutaneous vessels, and from its

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* Hence the danger of contagion from hairs, as miasmata adhere to them very tenaciously for a great length of time. Vide Cartwright, *Journal of Transactions on the Coast of Labrador.* vol. i. p. 273. vol. ii. p. 424.

† *Ars* Sanctor. Sanctorii *de Statica Medicina aphorismor. sectionibus vij. comprehensa.* Venet. 1634. 16.

‡ C. de Milly and Lavoisier, *Mémoires de l'Acad. des Sc. de Paris.* 1777, p. 221 sq. 360 sq. J. Ingen-Houz, *Expts. upon Vegetables.* Lond. 1779. 8vo. p. 132 sqq. J. H. Voight, *Versuch einer neuen Theorie des Fevers.* p. 157 sq.

§ W. Bache, *On the morbid effects of Carbonic Acid Gaz on healthy animals.* Philadel. 1794. 8vo. p. 46.

|| Abernethy, l. c.

hydrogen uniting with the oxygen of the atmosphere and assuming the liquid form.

195. Upon the same hydrogen, variously modified by the accession of other elements and constituents, would seem to depend the natural and peculiar odour perceived in the perspiration and sweat of certain nations and individuals.*

196. The quantity of matter perspired from the integuments which, in a well grown adult, are equal to 15 square feet, cannot be accurately estimated, but is probably about two pounds in 24 hours.† (D)

NOTES.

(A) One of this family has just been exhibiting himself in Bond Street. He is thirty years of age and states himself to belong to the fourth generation of the descendants of a savage who was found in the woods of America and had the same condition of skin. It is transmitted to every male without exception in the male line, but has never appeared in the females or their male offspring. The horny warts first show themselves at two

* Fr. L. Andr. Koeler, *De Odore per cutem spirante in statu sano ac morboso.* Gotting. 1794. 4to.

† The balance employed by Sanctorius to estimate the loss of perspired matter, is described in his *Comm. in* PRIMAM *Fen* PRIMI *L. Canon.* AVICENNÆ. Venet. 1646. 4to. p. 781.

Another much simpler and better adapted for the purpose, is described by Jo. Andr. Segner, *De Libra, qua sui quisque corporis pondus explorare posset.* Gotting. 1740. 4to. J. A. Klindworth, an excellent Gottingen instrument-maker, altered this at my suggestion, and rendered it more convenient and accurate.

months from birth, are constantly growing, though most in summer, and are constantly being shed, but particularly in winter, till the thirty-sixth year, after which they are never shed, but continue to grow, so that in this man's father, who is eighty years of age and lives in Suffolk, they are of very great length. They are set so close together, that their tops form a tolerable surface, unless they are separated by extending the skin. Nearest those parts which are natural, they gradually become smaller. The glans penis should have been excepted by Blumenbach as well as the scalp, face, palms, and soles.

(B) Although Dr. Gordon * and Mr. Lawrence † assert that they have never been able to detach any thing from the cutis of Europeans in the form of a distinct membrane, the rete Malpighianum does exist in Negroes, and the latter gentleman allows that the various complexions of Europeans and the peculiar cream white of the Albino who has unquestionably no colouring matter in his eyes or skin, show that it exists even in us.

(C) The illustrious Dr. Wells describes the singular case of a man whose hair fell off throughout his body in about six weeks, without any evident cause or derangement of health. He always looked afterwards as if just shaved, and by wearing a wig would not have been noticed for any peculiar appearance. ‡

(D) The functions of the skin are but imperfectly known. Besides forming a watery secretion (193 sq.) § and producing

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* *System of Anatomy.* Vol. i. p. 242.

† Rees's *Cyclopædia.* art. Integuments.

‡ *Transactions of a Society for the Improvement of Medical and Surgical Knowledge.* vol. ii.

§ Lavoisier and Seguin (*Mémoires de l'Academie des Sciences.* 1790. p. 610) inclosed the body in a silk bag varnished with elastic gum, having a small opening carefully cemented around the mouth, so that by weighing the body previously and subsequently to the experiment, they were able to ascertain exactly what had been lost by vapour, and by subtracting from this loss the weight of the perspired contents of the bag, they also ascertained how much of this had passed off by the lungs. From repeated trials they found the mean chemical changes similar to those which occur in the lungs (171),* it is believed by some to be an organ of absorption, while others deny that absorption ever takes place unless friction is employed or the cuticle abraded. Dr. Currie's patient labouring under dysphagia seated in the œsophagus, always found his thirst relieved by bathing, but never acquired the least additional weight.† Dr. Gerard's diabetic patient weighed no more after cold or warm bathing than previously.‡ Seguin found no mercurial effects from bathing a person in a mercurial solution, provided the cuticle remained entire; they occurred, however, when the cuticle was abraded.§

But the two former cases are no proofs that water was not absorbed, because the persons immersed did not lose in weight, which they would have done if not immersed, owing to the pulmonary excretions; this therefore must have been counterbalanced by absorption somewhere, and no shadow of proof can be urged against its occurrence by the skin, as Dr. Kellie remarks in his excellent paper on the functions of this part.|| Seguin besides found two grains of the mercurial salt disappear in an hour from the solution when of the temperature of 18° Reaumur.

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pulmonary discharge in twenty-four hours amounted to 15 oz. and the cutaneous to 1 lb. 14 oz. The quantity of carbon separated by the lungs ought however to have been taken into the account. If it amounts to 5½ oz. in twenty-four hours,—half the quantity stated by Allen and Pepys, but probably nearer the truth, there will be but 9½ oz. of pulmonary exhalation. They found the cutaneous transpiration at its maximum immediately after dinner, and at its minimum during digestion. The matter of transpiration contains an acid, probably the lactic, a muriate of potash and soda, lactate of soda, and perhaps albumen. Berzelius, *Animal Chemistry*. 95.

* Cruikshanks on *Insensible Perspiration*, and Ellis, *Further enquiry on the Changes produced in Atmospheric Air*, &c.

† *Medical Reports*, &c.

‡ Rollo, *On Diabetes*.

§ *La Médecine eclairée*, &c. T. 3.

|| *Edinburgh Med. and Surg. Journal.* vol. i.

There is every reason to believe the occurrence of cutaneous absorption independently of friction or abrasion of the cuticle. First, the existence of absorbents all over the surface cannot be intended for use merely when friction is employed or the cuticle abraded. Secondly, we have many facts which prove absorption without these circumstances, either by the skin or lungs or both, while no reason can be given why they should be attributed solely to the lungs. A boy at Newmarket who had been greatly reduced before a race, was found to have gained 30 oz. in weight during an hour, in which time he had only half a glass of wine.* Dr. Home, after being fatigued and going to bed supperless, gained 2 oz. in weight before seven in the morning.* In three diabetic patients of Dr. Bardsley's, the amount of the urine exceeded that of the ingesta, and the body even increased in weight, and in one of the instances as much as 17 lbs.† Dr. Currie allows that in his patient, "The egesta exceeded the ingesta in a proportion much greater than the waste of his body will explain." Similar facts are recorded by De Haen, Haller, &c. The same patient's urine too after the daily use of the bath, flowed more abundantly and became less pungent.

* Bishop Watson, *Chemical Essays.* vol. iii. p. 101.

† *Medical Facts and Experiments.*

SECT. XII.

OF THE FUNCTIONS OF THE NERVOUS SYSTEM IN GENERAL.

197. We now come to the other class of functions termed *animal* (83, II.), by which the body and mind are connected. They have obtained their name from existing in animal systems only, and from enjoying a greater range than those properly denominated vital.

198. The principal organs of these functions are the brain, medulla spinalis, and the nerves, the greater part of which originate from the two former.* They may be properly referred to two classes, *sensorial* and *nervous:* the former comprehending all excepting the nerves and their immediate origin,—all that serves more directly as the connection between the office of the nerves and the faculties of the mind.

199. Upon this division rests the beautiful observation of the illustrious Sömmerring† respecting the correspondence between the relative size of each class with the faculties of the mind,—That the smaller the nerves are, compared with the sensorial class, the greater is the developement of the mental faculties. In this sense, man has the largest brain of all animated beings,

* Eustachius, tab. xviii. fig. 2.

† *Diss. de basi encephali.* Gotting. 1778. 4to. p. 17. Also his work, already quoted, upon the anatomy of the negro. 59 sq.

J. Gotter. Ebel, *Observationes neurologicæ ex anatome comparata.* Traj. ad Viadr. 1788. 8vo.

—if its bulk be compared with that of the nerves arising from it; but by no means, if its weight be compared with that of the whole body.

200. Besides the bony cranium, a threefold covering is afforded to the brain,* viz. the dura and pia mater, and, between these two, the tunica arachnoidea.

201. The *dura mater,*† which lines the inside of the cranium, like a periosteum, forms various processes. By the falx it divides the hemispheres of the cerebrum and cerebellum; by the tentorium‡ it supports the posterior lobes of the cerebrum and prevents their pressure upon the subjacent cerebellum.

In its various duplicatures it contains and supports the venous sinuses§ and prevents their pressure. These receive the blood returning from the brain to the heart, the proportion of which to the rest, Zinn long ago very truly remarked, has been overrated by physiologists.

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* Eustachius, tab. xvii. xviii.

Haller, *Icones anat.* fasc. vi. tab. i. ii. iii.

Santorini, tab. posth. ii. iii.

† J. Ladmiral, *Icones duræ matris in concava et convexa superficie visæ.* Amst. 1738. fasc. i. ii. 4to.

‡ In the skulls of some mammalia, a remarkable lamina of bone penetrates a duplicature of the tentorium and supports it. Cheselden (*Anat. of the Bones.* chapt. 8.) supposes this bony tentorium to exist in *feræ* only; but it is found in the equine genus, the cercopithecus paniscus, the delphinus phocæna, &c. Its use is uncertain: that which is generally ascribed to it (for instance, by Laur. Nihell, *de cerebro.* Edin. 1780. p. 4.),—of protecting the cerebellum in those mammalia which move very swiftly, is improbable, because we find it in the bear and other animals of still slower motion, and not in the ibex, which moves with the greatest rapidity.

§ Vieussens, *Neurograph. universal.* tab. xvii. fig. 1.

Duverney, *Œuvres anatom.* vol. i. tab. iv.

Haller, *Icones anat.* fasc. i. tab. vi.

Walter, *De morbis peritonæi et apoplexia.* Berol. 1785. 4to. tab. iii. iv.

Vicq. d'Azyr, *Planches Anatomiques.* xxxii. et xxxv.

202. Next to the dura mater lies the *arachnoid*, so named from its thinness. Its use is not exactly known; it is destitute of blood-vessels (5), and extended, like the dura mater, merely over the substance of the brain, without following the course of its furrows and prominences.

203. On the contrary, the membrane called *pia mater* by the ancients, closely follows the cortical substance of the brain,* and possesses innumerable blood-vessels which penetrate into the latter. Hence, if a portion of this membrane is detached, we find the external surface very smooth, while the internal is villous and resembles the roots of moss.† (A)

204. The cerebrum and cerebellum are composed of various parts which differ in texture and figure, but the use of which is unknown. The most remarkable are the four ventricles,‡ in the two anterior and fourth of which are found the choroid plexuses, of whose function also we are ignorant. §

205. The substance of the brain is twofold: the one called cineritious or cortical, though not always situated exteriorly; the other white or medullary. Between the two, Sömmerring || has detected a third substance, most conspicuous in the arbor vitæ of the cerebellum and the posterior lobes of the cerebrum.

* Ruysch, *Respons. ad ep. problemat. nonam.* Amst. 1670. tab. x.

† B. S. Albinus, *Annot. Acad.* L. 1. tab. ii. fig. 1. 5.

‡ S. Th. Sömmerring, *über das Organ der Seele.* Kœningsberg. 1796. 4to. tab. i. ii.

§ The importance of these plexuses is shewn in the dissection of maniacs, in whom they alone are very frequently found diseased.

|| *De basi encephali.* p. 13.

Compare Genari, *De peculiari structura cerebri.* Parmæ. 1782. 8vo. tab. ii. iii.

206. The proportion of the cineritious * to the cortical substance decreases as age advances, being greater in children, less in adults. It is almost wholly composed of very fine vessels, both sanguiferous † and colourless (92), of which some few penetrate into the medullary substance: ‡ the latter is composed, in addition to these vessels and a fine cellular substance, of a pultaceous parenchyma, which, if examined with glasses, exhibits no regular structure, § and, upon chemical analysis, affords a peculiar matter, in some measure resembling albumen. (B)

207. The brain, after birth, undergoes a constant and gentle motion, || correspondent with respiration; so that, when the lungs shrink in expiration, the brain rises a little, but when the chest expands, it again subsides.**

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* Malpighi, *De cerebri cortice;* and his other *Exercitationes de viscerum structura.* Lond. 1699. 12mo.

Ruysch, *De cerebri corticali substantia ep. problemat.* xiima. Amst. 1699. 4to.

Chr. Frid. Ludwig, *De cinerea cerebri substantia.* Lips. 1799. 4to.

† Sömmerring, *De habitu vasorum cerebri* in *Denkschriften der Acad. der Wiss. zu München.* 1808. tab. i.

‡ B. S. Albinus, *Annat. Acad.* L. 1. tab. ii. fig. 4. 5.

§ Consult Metzger, *Animadversiones ad doctrinam nervorum.* Regiomont. 1783. 4to.

|| T. Dan. Schlichting first accurately described this striking phenomenon, *Commerc. litter. Noric.* 1744. p. 409 sq. and more largely, *Mém. presentées à l'Acad. des S. de Paris.* T. 1. p. 113.

Haller discovered the cause of it by numerous dissections of living animals. J. Dit. Wolstorf, his pupil, *Experimenta circa motum cerebri, cerebelli,* &c. Gotting. 1753.

Consult also, after F. de la Mure's works, Lorry's Dissertations on the same point, *Mém. Presentées.* T. iii. p. 277 sq. 344 sq. Also Portal on a similar motion observable in the spinal marrow, *Mém. de la Nature de plusieurs Maladies.* T. ii. p. 81.

** I once enjoyed an opportunity of very distinctly observing this motion and

208. The *spinal* marrow is continuous with the brain,* and may be said either to spring from the brain, as from a root, or, on the contrary, to terminate in it and grow into its substance.† Contained in the flexible canal of the vertebræ, it is enveloped by the same membranes as the brain: its substance is also twofold, but the medullary is exterior to the cineritious.

209. From these two sources—the brain and spinal marrow, arises the greater part of those chords, which are more or less white and soft, chiefly composed of cellular canals containing nervous medulla,‡ and distributed throughout nearly all the soft parts: some *nerves*,§ however, may be more properly considered as uniting with the brain and spinal marrow than springing from them. (C)

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making some experiments with respect to it, in a young man eighteen years old. When under five years of age, he had fallen from an eminence and fractured the frontal bone on the left side of the coronal suture, since which time there had been an immense hiatus, covered by merely a soft cicatrix and the common integuments. The hiatus formed a hollow, deeper during sleep, and varying according to the state of expiration; very deep if he retained his breath; much more shallow, and even converted into a swelling, by a long continued expiration. At the bottom of the hollow, I observed a pulsation synchronous with the pulsation of the arterial system, such as deceived Petrioli, Vandelli, and others, at one time the adversaries of Haller, who all confounded it with that which depends upon respiration.—I may add, that this wound on the *left* side of the head, had rendered the *right* arm and leg paralytic.

* J. J. Huber, *De medulla spinali.* Gotting. 1741. 4to. The plate is to be found among Haller's fascic. i. tab. ii.

Haller's own plates of the same part are in the same fasciculus, vii. tab. iv. v. Monro (filius), *On the Nervous System.* tab. x. fig. 1.

† Consult the *Anatomie et Physiologie du systeme Nerveux,* &c. *par* F. J. Gall et G. Spurzheim. T. i. Paris. 1810. 4to.

‡ Reil, *De Structura Nervorum.* Hal. 1796. fol.

Osiander, *Comm. Soc. Reg. Sc. Gotting.* T. xvi.

§ Rob. Martin's oration *De Proprietatibus Nervorum generalioribus.* prefixed to his *Instit. Neurologicæ.*

210. After the numerous experiments* made by Haller and other very careful observers, we are certain, from minute anatomical examination, that many of the similar parts do not exhibit any true vestige of nerves; and from surgical observation† and dissections of living animals,‡ that they do not evince the least sign of feeling.

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* Haller on the sensible parts of the body, *Comment. Soc. Sc. Gotting.* T. i. and his discourse upon them, *Nov. Comment. Gotting.* T. iii.

Peter Castell, *Experim. quibus constitit varias h. c. partes sentiendi facultate carere.* Gotting. 1753. 4to. And three entire collections on the controversies excited by the Gottingen publications throughout Europe.

Sull' insensibilita e irritabilita, dissertazioni transportate da J. G. V. Petrini. Rom. 1755. 4to.

Sulla insensitivita ed irritabilita Halleriana opuscoli raccolti da G. B. Fabri. Bologna. 1757—59. IV vol. 4to. And that which Haller himself published under the title of *Mémoires sur la nature sensible et irritable des parties du corps humain.* Lausanne. 1756—59. IV vol. 12mo.

† Amidst the great variety and even contradiction of opinion, which, as we shall presently mention, exists with respect to the feeling of tendons and other parts when injured, I have always considered negative arguments of more weight than positive, because nothing is more fallacious than the ideas of patients as to *the seat of internal pains.* To say nothing of cases where amputated parts appear to the patient as still in possession of feeling, it is well known that some have felt a fixed pain for a great length of time in parts where after death nothing uncommon was observable; and that, on the other hand, in chronic diseases, pain is sometimes felt not in the diseased part, but in another which is healthy and perhaps very remote.

We may in this way much more easily explain syphilitic pains, for instance, referred to the bones, than the result of so many contradictory experiments, in which I have seen the medulla of the human subject roughly handled without causing the least uneasiness.

‡ I am every day more convinced that much caution, and practice, and repetition of the same experiment in many different kinds of animals, are necessary in establishing the laws of physiology from dissections of living animals. To adduce the example of the supposed feeling of the medulla, I have found different results in many mammalia and birds. Many allowed the medulla to be destroyed without evincing any symptom of pain; others were convulsed,

Such are the cellular substance, the epidermis and reticulum mucosum, the hairs and nails.

The cartilages, bones, periosteum, and marrow.

The tendons, aponeuroses, and ligaments.

Most extended internal membranes, as the dura mater and arachnoid; the pleura, mediastinum, and pericardium; the peritonæum; also the cornea, &c.

The greater part of the absorbent system, especially the thoracic duct.

Lastly, the secundines and umbilical chord. (D)

211. The ultimate origin of most nerves from the brain cannot be detected. A question is agitated even at the present day,—whether the nerves of each side arise from the corresponding or the opposite portion of the brain.* The latter opinion is countenanced by certain pathological phenomena,† and by the decussation of fibres in the medulla oblongata‡ and conjunction of the optic nerves.§ (E)

212. A continuation of the pia mater follows the me-

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and cried out on the approach of the instrument. The latter might be agitated from the dread of fresh torment, on seeing the knife; and the former, having suffered great torture, might have been insensible to the less violent irritation of the medulla, even although it be endowed with nerves.

* Lassus has diligently collected the different opinions of writers on this point, *Sur les découvertes faites en Anatomie.* p. 299 sq.

† Compare Mein. Sim. Du Pui, *De homine dextro et sinistro.* LB. 1780. 8vo. p. 107 sq.

‡ v. Gall and Spurzheim, and likewise Osiander. ll. cc.

§ Sömmerring, *Hessischen Beyträgen zur Gelehrsamkeit.* P. i. and iv.

F. N. Nöthig, (præs. Sömmerring) *De decussatione nervorum optic.* Mogunt. 1786. 8vo.

J. F. Ackermann in the *Biblioth. Medica* which I published. vol. iii. p. 337, 706.

Hor. Caldani, *Opuscula Anatomica.* Patav. 1803. 4to. p. 111.

J. and C. Wenzel, *Prodromus eines Werkes über das Hirn.* p. 11.

dulla of the nerves at their commencement,* in such a way, as to unite very delicately with the vascular cortex.† But as soon as they have quitted the brain or medulla spinalis, their structure becomes peculiar, different from that of all the other similar parts. They form transverse folds more or less oblique and angular, long since described by P. P. Mollinelli,‡ who not inaptly compared them to the rugæ of earth-worms or the rings of the aspera arteria.

213. The nerves, especially those which are remarkable, for instance, the intercostals and par vagum, are here and there furnished with *ganglia*, or nodules of a compact structure and reddish ash colour, but with whose functions we are scarcely acquainted. I am inclined to believe with Zinn § that they more intimately unite the nervous filaments which meet in them from various directions, so that each fibre passing out is composed of a portion of every fibre that has entered in.||

Nearly the same holds good with respect to the plex-

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* Consult Pfeffinger, *De structura Nervorum*. Argent. 1782. 4to.

† Wm. Battie, *De Principiis Animalibus*. p. 126.

‡ *Comment. Instituti Bononiens*. T. iii. 1755. p. 282 sq. fig. 1, 2.

The observation of Mollinelli has been abundantly confirmed and further illustrated by Felix Fontana and Al. Monro: by the latter in his work so often quoted, and by the former in his treatise *Sur le Vénin de la Vipère*. Flor. 1781. 4to., vol. ii.

§ *Mém. de l' Acad. des Sc. de Berlin*. Vol. ix. 1753.

|| Consult among others who treat professedly of the ganglia, J. Johnstone, *Med. Essays and Observ*. Evesham. 1795. 8vo.

J. Gottl. Haase's Dissertation. Leipz. 1772. 4to.

T. Caverhill, *Treatise of Ganglions*. Lond. 1772. 8vo.

Ant. Scarpa, *Anatom. Annotat*. L. i. *de nervor. Gangliis et Plexubus* Mutin. 1799. 4to.

G. Prochaska, *De structura nervorum*. Vindob. 1780. 8vo. Al. Monro, l. c.

uses, which are produced by the union and reticulated anastomoses of different nerves and by a similar contexture of filaments into which the nerves are split.

214. The ganglia and plexuses are most abundantly bestowed upon the spinal nerves and the intercostal or sympathetic nerve. The latter, united by a few delicate filaments only with the rest of the nervous system, constitutes a peculiar system, chiefly belonging to the involuntary functions. For this reason, Bichât, viewing it as presiding over *organic* life, distinguished it from the other nerves belonging to *animal* life, to use his own language.*

215. The terminations of the nerves are no less concealed from us than their origins. Excepting a few which spread out in the form of membranes, as the optic nerve which becomes the retina, and the portio mollis of the seventh pair which forms a zone in the spiral lamina of the cochlea, the ultimate filaments of the rest penetrating into the viscera, muscles, corium, &c. are so intimately blended with the substance of these parts as to elude observation.

216. The parts just described, viz. the sensorium and the nerves originating in it and distributed throughout the body, constitute that system which, during life, is the bond of union between the body and the mind.

217. That the mind is closely connected with the brain, as the material condition of mental phenomena, is demonstrated, to omit such arguments as the immediate connection between the brain and the organs of sense, by our consciousness and by the mental disturbances which ensue upon affections of the brain. (F)

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* See Reil, *Archiv für die Physiologie*. T. vii. p. 189.

218. The singular situation and form, before alluded to, of certain parts of the brain, and likewise some pathological phenomena, have induced physiologists to suppose certain parts, in particular, the seat of the soul. Some have fixed upon the pineal gland,* others the corpus callosum,† the pons Varolii, the medulla oblongata, the corpora striata, and the water of the ventricles, which washes against the origin of some nerves. Others not contented with one spot, have assigned particular parts of the brain for individual faculties and propensities. (G)

219. The energy of the whole nervous system does not depend solely upon the brain. The spinal marrow, and even the nerves, are possessed of their own powers, which are sufficient to produce contractions in the muscles. These powers are probably supported by the vascular cortex of those parts (212). In man, the powers proper to the nerves are less, and those dependent upon the brain greater, than in brutes, especially the cold-blooded.

220. The office of the whole nervous system is two-fold,—To excite motion in other parts, especially in the voluntary muscles, of which we shall hereafter speak at large; and to convey impressions made upon the organs of sense to the brain, and there to excite per-

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* The Cartesian hypothesis appeared to receive some weight from the dissection of maniacs, in whom the pineal gland was found full of calcareous substances. But more careful observation shewed, that, after the twelfth year, it was generally filled with a pearly sand, in the healthiest persons, though very seldom in brutes. Sömmerring, *De lapillis vel prope vel intra glandulam pinealem sitis, s. de acervulo cerebri.* Mogunt. 1785. 8vo.

† The prerogative of this part was ably refuted by Zinn, *Exp. circa corpus callosum, cerebellum, duram meningem, in vivis animalibus instit.* Gott. 1749. 4to.

ception or by means of sympathies (56) to give occasion to reaction.

221. Experiment and observation put these functions of the nervous system beyond the reach of controversy. To unfold their nature is difficult indeed. (H)

222. Most opinions on this subject may be divided into two classes. The one regards the action of the nervous system as consisting in an oscillatory motion: The other ascribes it to the motion of a certain fluid, whose nature is a matter of dispute, by some called animal spirits * and supposed to run in vessels, by others conceived to be a matter analogous to fire, to light, to a peculiar ether, to oxygen, to electricity, or to magnetism.

223. Although I would by no means assent to either of these opinions, I may be allowed to observe, that most arguments brought by one party against the hypothesis of the other, must necessarily be rude in proportion to the subtlety of the oscillations (if such exist) of the nerves or the nervous fluid.

224. These two hypotheses may, perhaps, be united by supposing a nervous fluid thrown into oscillatory vibrations by the action of stimulants.

225. The analogy between the structure of the brain and some secreting organs, favours the belief of the existence of a nervous *fluid*. But tubes and canals are evidently no more requisite for its conveyance, than they are requisite in bibulous paper or any other matter employed for filtering.

The opinion receives much weight from the resem-

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* See Michelitz, *Scrutinium Hypothescos Spirituum Animalium.* Prag. 1782. 8vo.

blance of the action of the nerves to the phenomena produced by the series of a galvanic apparatus and by the common electrical machine,* in a living animal or in parts not quite deprived of vitality. These phenomena in fact long ago induced some physiologists to compare the nervous to the *electric* fluid. The singular and undeniable effects attributed to *animal magnetism,*† as well as other phenomena which have given rise to the belief of a kind of sentient atmosphere surrounding the nerves,‡ agree very well with the same hypothesis.

226. If we regard the *oscillation* of the nerves, not as similar to that which occurs in tense chords, but of such a description as may be conceived to occur in the soft pulp of the brain, we shall find many physiological phenomena exactly corresponding with the supposition.

It is demonstrated that hearing depends upon an oscillation.

In vision also it probably occurs, although not to the extent imagined by Euler.

The penetration of Hartley § in following up the conjectures of the Great Newton, || has rendered it so probable that the action of the other senses is not very

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* Fr. Al. Von Humboldt, *über die gereizte Muskel und Nervenfafer.* Posen. 1797. ii vol. 8vo.

J. W. Ritter, *Beweis dass ein beständiger Galvanismus den Lebensprocess im Thierreiche begleite.* Vinar. 1798. 8vo.

† J. Heineken, *Ideen u. Beobachtungen den thierischen Magnetismus betreffend.* Brem. 1800. 8vo.

‡ v. Humboldt and Heineken, ll. cc.

§ Dav. Hartley, *Observat. on Man, his Frame, his Duty, and his Expectations.* Lond. 1749. 8vo. vol. i. p. 44.

|| *Queries* at the end of his *Optics.* Qu. 23. p. 355. Lond. 1789. 8vo.

dissimilar from this oscillatory motion, that on the same supposition he very ingeniously explains, principally by means of the vapour of the ventricles (called by him the denser ether),* first, the association of ideas, and again, by the assistance of this, most of the functions of the animal faculties. (I)

NOTES.

(A) The *Pia Mater* and *Tunica Arachnoides* were considered as the same, till the Anatomical Society of Amsterdam confirmed, in 1665, the doubts which were arising on the subject and Van Horne demonstrated both membranes distinctly to his pupils. The *Dura Mater* corresponds with the fibrous membranes, the *Pia Mater* with the cellular, and the *Tunica Arachnoides* with the serous. The latter is, in nature, office, and diseases, exactly like the serous;—a close sac, affording, as the peritonæum does to the abdominal viscera, a double covering to the brain and spinal marrow and the nerves before their departure through the foramina of the *Dura Mater*, and lining the ventricles; insulating the organs on which it lies, and affording them great facility of movement; and liable to all the morbid affections of serous membranes.†

(B) Fibres are very evident in the cerebral substance. Mr. Bauer has discovered globules, but then he finds fibres to be series of globules. ‡

* Er. Darwin has carried these opinions of Hartley still farther, *Zoonomia*. T. 1.

† Bichat, *Traité des Membranes.*

‡ *Phil. Trans.* 1818.

(C) Drs. Gall and Spurzheim have shewn that the nerves and spinal marrow do not arise from the brain, but only communicate with it: for, when the brain is absent, the fœtus equally possesses them, and neither the cerebral nerves nor the spinal marrow are in proportion to each other in the various species of the animal kingdom, nor the spinal nerves to the spinal marrow.

(D) Although no nerves can be discovered in these parts, and although ordinarily they have no feeling, yet that they have, in a lower degree, what, in a higher is called feeling, is shewn by the extreme sensibility which they acquire when inflamed, as they nearly all frequently are.

(E) Drs. Gall and Spurzheim have also shewn that, besides the numerous communications of the whole nervous system, not only the two sides of the cerebrum, cerebellum, and spinal marrow, are united by commissures, but that the fibres of the anterior pyramidal eminences decussate each other, forming an exception to the rule, observed in every other part of the brain, of the nervous fibres, destined to each side of the body, running on the same side of the brain; and they hence explain why injuries of one side of the brain sometimes influence the same, sometimes the opposite, side of the body. It is to be hoped that morbid dissection will ascertain the correctness of this explanation.

I refer to the writings of these physicians for an account of their great discoveries in the structure of the nervous system, and shall merely bear testimony to the truth of most of their anatomical assertions. Those few which I have not repeatedly seen proved, are I doubt not perfectly accurate. The most candid anatomical lecturers of London confess that they knew nothing of the anatomy of the brain till they saw it dissected by Dr. Spurzheim, and it is a matter of wonder that while pupils are not instructed to dissect limbs by slices as we cut brawn, they should be taught no other mode of examining the brain and thus be left in ignorance of its true structure.*

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* *Anatomie et Physiologie du Systeme nerveux* par Gall et Spurzheim, and *Physiognomical System* by Spurzheim.

(F) See Sect. VI. Note A, near the end; and Sect. XLIV. Note E, near the beginning.

(G) Dr. Gall has the immortal honor of having discovered the particular parts of the brain which are the seat of the different faculties, sentiments, and propensities.

If it is clear that the brain is the organ of mind, it is extremely probable that particular portions of it have different offices.

Numerous old writers had assigned situations for the faculties, but in the most fanciful manner; and from regarding as distinct faculties what are merely modes of action of faculties to which they were altogether strangers, their assertions on the subject were necessarily groundless and ridiculous. Burton, for example, says of common sense, "the fore-part of the brain is his *organ* or seat;" of imagination, "his *organ* is the middle cell of the brain;" and of memory, "his seat and *organ*, the back part of the brain." *

If the old course, recommended by Mr. Dugald Stewart, of investigating the mind by attending to the subjects of our own consciousness, had been persevered in, the science of mind would have remained stationary for ever. † Who can judge fairly of

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* *Anatomy of Melancholy.* P. 1. S. 1. Mem. 2. Subs. 7.

† Although Mr. Dugald Stewart declares that in his own inquiries he has "aimed at nothing more than to ascertain, in the first place, the laws of our constitution, as far as they can be discovered by attention to the subjects of our own consciousness;" (*Essays. Preliminary dissertation.* p. 2.) that "the whole of a philosopher's life, if he spends it to any purpose, is one continued series of experiments on his own faculties and powers;" (p. 40.) and that "the structure of the mind (whatever collateral aids may be derived from observing the varieties of genius in our fellow-creatures) is accessible to those only who can retire into the deepest recesses of their own internal frame;" yet he adds "even to those, presenting, along with the generic attributes of the race, many of the specific peculiarities of the individual," (*Elements.* vol. i. p. 513.) and has really the following passage in the forty-second page of the *Essays.* "To counterbalance the disadvantages which this science of mind lies under, in consequence of its slender stock of experiments, made directly and intentionally on the minds of our fellow-creatures, human life exhibits to our observation a bound-

his own character and talents? Not only is the heart of man deceitful above measure, but we give ourselves credit for talents which others know to be insignificant. Our powers too and dispositions are distributed in such various degrees, that from this single circumstance, every man, judging from himself only, would draw up a different account of the human mind. It is only by extensive observation of others, of different sexes, ages, education, occupations, and habits, that this knowledge is to be acquired. Nor would much progress have been made without the discovery—that strength of individual talent and disposition was associated with proportionate developement of particular portions of the brain. By this remark the existence of particular faculties and inclinations was firmly established. I made no allusion to craniology while detailing Dr. Spurzheim's account of the mind (Sect. V.), because the arrangement may be perfectly accurate, although craniology be false; nor when speaking of the brain as the organ of the mind (Sect. VI.), because that fact also is independent of the system. But if now the account of the mind, the use of the brain, and craniology, be viewed together, they will all be seen mutually and beautifully to confirm each other.

Much disgraceful invective, but no argument, has been written against the doctrine. We are presented with a simple statement—that strength of certain parts of the mind, is accompanied by strong developement of certain parts of the brain, and, conse-

less variety, both of intellectual and moral phenomena, by a diligent study of which, we may ascertain almost every point that we could wish to investigate, if we had experiments at our command." "Savage society, and all the different modes of civilization; the different callings of individuals, whether liberal or mechanical; the prejudiced clown, the factitious man of fashion; the varying phases of character, from infancy to old age; the prodigies effected by human art, in all the objects around us, laws, government, commerce, religion; but above all, the records of thought preserved in those volumes which fill our libraries, what are they but experiments, by which nature illustrates, for our instruction, on her own grand scale, the varied range of many intellectual faculties, and the omnipotence of education, in fashioning the mind."

quently, of the skull. The truth must be ascertained, not by fancying, quibbling, and abusing, but by observing whether this is the case: and every one has it in his power to make the necessary observations. I had heard of a religious bump, a thievish bump, and a murderous bump, and was as lavish of my ridicule and contempt of Dr. Gall's doctrine as any one, till I heard Dr. Spurzheim's lectures in the Medico-Chirurgical Society. His modesty, candour, and sound sense, struck me powerfully; his anatomical facts were demonstrated; his metaphysics were simple and natural; and the truth of his craniology was evidently to be ascertained by personal observation only. I commenced observations, and so satisfied was I of its correctness, that whilst the storm was raging violently against the German physicians, I wrote an anonymous defence of them in the only review that declared itself their friend. Three years have now elapsed, and my observations have been much extended, but they all confirm Dr. Spurzheim's statements. Of the accuracy of his general division of the organs, and of the situation of many particular ones, I am quite certain. Upon some organs I have not yet made sufficient observations, and I have no doubt that our views of the functions of many organs will be much modified and improved. It would be absurd to think the system perfect at present. The wonder is that so much has been already done, and that by only two individuals. The whole praise of discovery belongs to Dr. Gall, but Dr. Spurzheim has made such advances and improvements as to have almost equal merit. The science of craniology is entirely theirs; nearly so henceforward will metaphysics be regarded; and anatomy must acknowledge them among its greatest benefactors. Those who wish to become acquainted with craniology I must refer to Dr. Spurzheim's well known English work,* and to a very clear, forcible, and temperate publication, by Mr. Coombe, a surgeon in Edinburgh.† Who-

* *The Physiognomonical System* of Drs. Gall and Spurzheim.

† *Essays on Phrenology, or an enquiry into the principles and utility of the system of Drs. Gall and Spurzheim, and into the objections made against it.* Edinburgh. 1819.

ever acquires sufficient knowledge of the subject to make observations for himself, will soon find the shape of the skull to be as various as character and countenance, and will have hourly amusement not only in remarking the relation between mental character and cranial form, but in tracing the resemblance of children in the latter respect to their parents, as well as in talent and disposition. I find nothing more interesting than to note the increase of particular portions of the skulls of children as their minds become developed. It has been asserted that, after a certain age, (though this has been very differently fixed) the brain makes no farther increase in weight; but I know that various parts of the brain are variously evolved from infancy to manhood, and that, if children of different ages and young persons are placed side by side, the greater magnitude of the forehead in the older is strikingly conspicuous.

Should any one doubt his acquaintance with the real talents and characters of those friends whose heads he can select for observation, he has only to study the heads of some celebrated men now living, of whose talents and disposition no one can have the slightest doubt, and he will find the illustration astonishing.

If these are facts, all objections on the score of fatalism, &c. however correct, are unworthy of attention. But in truth, craniology gives no additional support to such views. A stone is destined not to feel; a fish is destined to swim, and a vulture to be a bird of prey; man is destined to be

> "Not prone and brute as other creatures, but endued
> With sanctity of reason, and to erect
> His stature, and upright with front serene,
> Govern the rest, self-knowing." *Parad. Lost.* vii.

The very expression "human nature" implies certain innate faculties and dispositions, generally; the circumstance of peculiar degrees of disposition and talents being hereditary and of each age having its distinctive character, are quite as favourable as craniology to the belief of fatalism. Each has his own talents and disposition; in some way or other they must be obtained, and if the way is discovered, the case does but remain the same as before.* But whatever may be our innate propensities and powers, we know how much various circumstances influence the developement of faculties and the strength of dispositions, and we know that we are free agents: we can move our right hand or our left, and sit still or walk, exactly as we chuse, and we possess conscience to guide our conduct.

> "Reason in man obscured or not obeyed,
> Immediately inordinate desires
> And upstart passions catch the government
> From reason: and to servitude reduce
> Man, *till then free.*" *Parad. Lost.* xii.

Those who have so little soul as always to ask what is the good of any discovery in nature, may be told that craniology is calculated to assist parents in the choice of occupations for their children. And it may be of much service in confirming some moral views which good sense indeed ought previously to have suggested. Humility and benevolence are two leading duties. If we detect the signs of mental deficiency and vice in our own heads, we may learn to think humbly of ourselves; and if we detect the signs of great talents and virtues in the heads of others, we may love them the more as superior and highly favoured beings: whereas if we detect the signs of great virtues and talents in our heads, we may learn to take no praise to ourselves, but be thankful for the gift; and if we detect the signs of intellectual deficiency and vice in others, we may learn to pity rather than to censure. We may learn not to judge others, nor even our own-selves, but to leave judgment to Him who only knows what natural strength of evil inclination, what weakness of

* All know that sexual desires are so connected with the genital organs as to commence when these become mature, and be prevented by their removal during childhood: but we do not therefore exculpate fornicators and adulterers. The circumstances are precisely the same with all the cerebral organs of propensity.

good, and what unhappy external circumstances, each has had to contend with. Not revenge, but example, is the professed object of our legal punishments :—example to the culprit himself and others, or, if the punishment is capital, to others only; and therefore frauds, which, from being very easily committed, may become very detrimental to society, are punished more severely than those which, cæteris paribus, from being difficult of perpetration, can scarcely from their frequency become dangerous. Were moral demerit regarded, the fraud easily committed, would, cæteris paribus, be punished the most lightly. A vicious man must sometimes be destroyed, as a wild beast,* for the good of others, though, for aught we know, his faults may, like the acts of the beast of prey, be chargeable rather on his nature; and while we feel justified in punishing, and the culprit is perhaps conscious how richly he deserves his fate, we may pity in our hearts and acknowledge that we ourselves have often been less excusable.

> "Teach me to love and to forgive,
> Exact my own defects to scan,
> What others are to feel, and own myself a man."
>
> Gray. *Ode to Adversity.*

(H) While the brain is evidently the organ of mind, the nerves united with it, and the spinal marrow, together with its nerves, are as evidently the instruments by which it affects, and is affected by, the other parts of the body, to which these nerves are distributed. By their instrumentality, the brain contracts the voluntary muscles, influences the functions of every other part when under the operation of the different passions, and receives impressions made upon every other part. The consequences of divisions of the nerves or spinal marrow, fully substantiate these points.

In brainless fœtuses, the circulation, secretion, &c. proceed equally as in others which, besides spinal marrow, nerves, and

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* A man of determined bad principle may in like manner be shunned by the most benevolent, on account of being odious and dangerous, though they wish him so well as ardently to long for his reformation.

ganglia, possess a brain. Vegetables absorb, assimilate, circulate, secrete, and in many instances contract on the application of stimuli, and yet are not known to possess nerves. Muscles, after the division of the nerves which connect them with the brain, contract equally as before, when irritated. In animals liable to torpor, the season of torpidity produces its effects equally upon those muscles whose nerves have been divided, or when the brain, &c. is destroyed.

After the removal or destruction of the brain and spinal marrow in animals, the heart still continues to act and the blood to circulate, provided respiration is artificially supported.* But the involuntary functions are closely connected with the brain and spinal marrow, for the sudden destruction of these parts or a certain portion of them, puts a stop to the circulation; † the application of stimuli to them excites the action of the heart and, even after its removal, of the capillaries; ‡ to say nothing of the influence of the passions upon them. Nay more, the involuntary functions seem as dependent upon the brain and spinal marrow as they probably are upon the ganglia and gangliac nerves, for the division of the par vagum, or the destruction of that part of the brain with which it is connected, heavily impairs the functions of the lungs and of the stomach; § and although the division of the spinal marrow, or its nerves, prevents voluntary power over the corresponding muscles, without suspending the circulation, &c. in them, yet this, and what are dependent upon it,—nutrition and animal heat, are evidently impaired, and more, I think, than can be accounted for by the mere deficiency of muscular action.

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* Experiments, &c. by A. P. Wilson Philip, M.D. and Wm. Clift, *Philos. Trans.* 1815.

† Le Gallois, *Sur le Principe de la Vie*; and Wilson Philip, l. c.

‡ Wilson Philip, l. c. Probably by excessive stimulus, as the voluntary muscles are afterwards insensible to stimuli, although, after a mere division of their nerves, they retain their excitability.

§ Le Gallois, l. c. and many former writers.

Much progress, surprisingly much, has been made of late in our knowledge of the functions of the nervous system, but great obscurity still hangs over the subject.

(I) These oscillations are purely hypothetical and indeed improbable. Were their existence proved, we should know nothing more of the real nature of the cerebral functions, for we should have to learn what were the peculiar properties of the nervous system, which enabled it alone of all substances to produce, when oscillating, the phenomena which it exhibits. We might as well attempt to explain the phenomena of motion or of chemical affinity and galvanism, by vitality and mind, as the phenomena of vitality and mind by mechanics or chemical affinity and galvanism. They are altogether distinct principles, although there can be no question that the laws of mechanics and chemical affinity and galvanism, are important and indispensable in every living system, in subservience to life and mind. The mind, for aught we know, may stimulate the voluntary muscles by means of galvanism communicated along the nerves, but then the galvanism is not mind, it is merely an instrument employed by the mind.*

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* The voluntary muscles contract for some time after death, when their nerves are galvanised; the involuntary will not, although for twenty-four hours after death the heart is excited on the contact of a mechanical or chemical irritant. v. c. Wilson, *Lectures on the Blood, &c.* p. 139.

When the stomach has suffered by the division of the par vagum, galvanism is said to enable it to perform digestion.

SECT. XIII.

OF THE EXTERNAL SENSES IN GENERAL, AND OF TOUCH IN PARTICULAR.

227. One office of the nerves we found to consist in communicating to the sensorium the impressions made by external objects. This is accomplished by the external senses, which are, as it were, the watchmen of the body and the informers of the mind.

The latter alone belong to our present subject. For to regard, with Gorter, the stimulus which inclines us to relieve the intestines, the sensation of hunger, and other internal calls of nature, as so many distinct senses, is unnecessary minuteness, as Haller long since observed.*

228. *Touch* merits our first attention, because it is the first to manifest itself, its organ is most extensively spread over the whole surface, and it is affected by most properties of external objects.

229. For we perceive not only some qualities, as heat, hardness, weight, &c. by the touch only, but our knowledge obtained by other senses respecting some qualities is rendered more accurate by the touch; such qualities are figure, distance, &c.

230. It is less fallacious than the rest of the senses, and by culture capable of such perfection as to supply the defects of others, particularly of vision.†

* J. De Gorter, *Exercitationes Medicæ.* iv. Amst. 1737. 4to.

† Consult Rol. Martin, *Schwed. Abhandl.* Vol. xxxix. 1777.

231. The skin, whose structure we formerly examined, is the general organ of touch.* The immediate seat is the papillæ of the corium, of various forms in different parts, commonly resembling warts,† in some places fungous,‡ in others filamentous.§ The extremities of all the cutaneous nerves terminate in these under the form of pulpy penicilli.

232. The *hands* are the principal seat of touch properly so called and regarded as the sense which examines solidity. The skin of the hands has many peculiarities. In the palms and on each side of the joints of the fingers, it is furrowed and free from hairs, to facilitate the closing of the hand. The extremities of both fingers and toes are furrowed internally by very beautiful lines more or less spiral;|| and are shielded externally by nails.

233. These scutiform *nails*** are bestowed upon man only and a few other genera of mammalia (we allude to the quadrumana which excel in the sense of touch),††

G. Bew, *Memoirs of a Society of Manchester.* Vol. i. p. 159.

Ch. Hutton, *Mathematical Dictionary.* Vol. i. p. 214.

* F. de Riet, *De Organo Tactus.* LB. 1743. 4to. reprinted in Haller's Anatomical Collection. T. iv.

† Dav. Corn. de Courcelles, *Icones Musculor. Capitis.* Tab. i. fig. 2, 3.

‡ B. S. Albinus, *Annotat. Academ.* L. iii. tab. iv. fig. 1, 2.

§ Ruysch, *Thesaur. Anat.* iii. tab. iv. fig. i. *Thes.* vii. tab. ii. fig. 5.

B. S. Albinus, l. c. L. vi. Tab. ii. fig. 3, 4.

|| Grew, *Philos. Trans.* n. 159.

** B. S. Albinus, *Annotat. Acad.* L. ii. tab. vii. fig. 4, 5, 6.

†† Namely simiæ, papiones, cercopitheci, and lemures, the apices of whose fingers in their four hands are very soft, and marked, as in the human subject, with spiral lines.

Physiologists have disputed whether the sense of touch is bestowed on any besides man and the *quadrumana.* In determining this controversy we must recollect what was formerly said (81) concerning the difference of constitution for the purpose of resisting pressure, and thus assisting the action of the fingers, while examining objects.

They are of a horny nature, but on the whole very similar to the epidermis. For under them lies the reticulum, which in negroes is black;* and under this is found the corium, adhering firmly to the periosteum of the last phalanx. These constituent parts of the nails are striated lengthwise. The posterior edge, which, in the hands, is remarkable for a little lunated appearance, is fixed in a furrow of the skin; and the nails are growing constantly from this, so as to be perfectly renewed about every six months.

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according to mode of life. On one side, I would grant to both parties that the snowy hands of a delicate girl must enjoy a much more exquisite sense of touch than what I called the fingers of animals. But, on the other, I have frequently seen simiæ and papiones possessing much softer fingers, and using these fingers to explore surfaces much more dexterously, than many barbarous nations and innumerable persons among the lower orders of Europeans whose hands have been hardened by labour.

* B. S. Albinus, *De Habitu et Colore Æthiopum.* fig. 3.

SECT. XIV.

OF TASTE.

234. We perceive tastes by the tongue and in some degree by the other neighbouring internal cutaneous parts of the mouth, especially by the soft palate, the fauces, the interior of the cheeks, and lips; by them, however, we taste only what is acrid and very bitter.*

235. The chief organ of taste is the *tongue*,† agile, obsequious, changeable in form, and, in its remarkably fleshy nature, not unlike the heart.

236. Its integuments resemble the skin. They are an epithelium, performing the office of cuticle; the reticulum Malpighianum;‡ and a papillary membrane, but little different from the corium.

237. The integuments of the tongue differ from the skin chiefly in these respects—in the epithelium being moistened, not by the oily fluid of the skin, but by a mucus which proceeds from the foramen cæcum of Meibomius § and the rest of the glandular expan-

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* Grew, *Anatomy of Plants.* p. 284 sq.

Petr. Luchtmans, *De Saporibus et Gustu.* LB. 1758. 4to. p. 58 sqq.

J. Gottl. Leidenfrost, *De sensu qui in faucibus est, ob eo qui in lingua exercetur, diverso.* Duisb. 1771. 4to.

† Sömmerring, *Icones Organorum Humanorum Gustus.* Francof. 1808. fol.

‡ In dogs and sheep with variously coloured skin, I have commonly found the reticulum of the tongue and fauces also of various colours.

§ Consult Just. Schrader, *Observat. et Histor.* from Harvey's book *De Generatione Animalium.* p. 186.

sion of Morgagni *—and, secondly, in the conformation of the papillæ, which are commonly divided into petiolated, obtuse, and conical. † The first are very few in number and situated in a lunated series at the root of the tongue; the others, of various magnitudes, lie promiscuously upon the back of the tongue, and chiefly upon its edges and apex, where taste is most acute. ‡

238. These papillæ are furnished with extreme filaments of the lingual branch of the fifth pair; § and through them we probably acquire the power of tasting.

The ninth pair, || and the branch of the eighth which also supplies the tongue,** appear intended rather for the various movements of this organ, in manducation, deglutition, speaking, &c.

239. For the tongue to taste properly, it must be moist, and the substance to be tasted must be liquid, holding salts in solution.†† (A) For if either is in a dry state, we may perceive the presence of the substances by the common sense of touch, which the tongue possesses in great acuteness, but cannot discover their sapid qualities. When the tongue tastes very acutely, the papillæ around its apex and margins are in some degree erected.

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* Morgagni, *Adversar. Anat. Prima.* Tab. i.

† Ruysch, *Thesaur. Anat.* 1. tab. iv. fig. 6.

B. S. Albinus, *Annotat. Acad.* L. i. tab. i. fig. 6—11.

‡ Consult Haller's excellent description of the tongue of a *living man*, in the *Dictionn. Encyclopédique.* Yverdon edition. Vol. xxii. p. 28.

§ J. F. Meckel, *De Quinto pare Nervorum Cerebri.* Gotting. 1748. 4to. p. 97. fig. 1. N. 80.

|| J. F. W. Böhmer, *De Nono pare Nervorum Cerebri.* Gotting. 1777. 4to.

** See Haller, *Icon. Anatom.* fasc. ii. tab. 1. letter g.

Monro, *on the Nervous System.* Tab. xxvi.

†† Bellini, *Gustus Organum novissime deprehensum.* Bonon. 1665. 12mo.

NOTE.

(A) Certainly an infinite number of bodies are sapid, which contain no kind of salt.

Some gases and metals are sapid; they however may possibly be united with the fluids of the mouth, before they produce an impression: but it is by no means proved that the moisture indispensable for taste is requisite to dissolve the substance tasted and not to fit the papillæ for their office.

SECT. XV.

OF SMELL.

240. While taste and smell are closely related by the proximity of their organs, they are not less so by the analogy of their stimuli and by some other circumstances. For this reason, they have been generally named chemical or subjective senses.

By smell we perceive odorous effluvia received by inspiration and applied principally to that part of the Schneiderian * membrane which invests both sides of the septum narium and the convexities of the turbinated bones.

241. Although the same mucous membrane lines the nostrils † and their sinuses, ‡ its nature appears different in different parts.

Near the external openings it is more similar to the skin, and beset with sebaceous follicles from which arise hairs known by the name of vibrissæ.

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* Conr. Vict. Schneider, *De Osse Cribriformi et Sensu ac Organo Odoratus.* Witteb. 1655. 12mo.

This classical work forms an epoch in physiological history, not only because it was the first accurate treatise on the function of smell, but because it put an end to the visionary doctrine of the organ of smell being the emunctory of the brain.

† Sömmerring, *Icones Organorum Humanorum Olfactus.* Francof. 1810. fol.

‡ Haller, *Icones Anat.* fasc. iv. tab. ii.

Duverney, *Œuvres Anatom.* Vol. i. tab. xiv.

Santorini, *Tab. Posthum.* iv.

On the septum and the turbinated bones it is fungous and abounds in mucous cryptæ.

In the frontal, sphenoidal, ethmoidal, and maxillary sinuses, it is extremely delicate, and supplied with an infinite number of blood-vessels which exhale an aqueous dew.

242. It appears the principal, not to say the sole, use of the sinuses,* to supply this watery fluid, which is perhaps first conveyed to the three meatus of the nostrils and afterwards to the other parts of the organ, preserving them in that constant state of moisture which is indispensable to the perfection of smell.

The sinuses are so placed, that, in every position of the head, moisture can pass from one or other of them into the organ of smell.

243. The principal seat of smell,—the fungous portion of the nasal membrane, besides numerous blood-vessels, remarkable for being more liable to spontaneous hemorrhage than any others in the body, is supplied by nerves, chiefly the first pair,† which are distributed on both sides of the septum narium, and also by two branches of the fifth pair. The former appear to be the seat of smell: ‡ the latter to serve for the common feeling of the part, which excites sneezing, &c.

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* In my *Prolus. de Sinibus Frontal.* Gotting. 1779. 4to. I have brought forward many arguments from osteogeny, comparative anatomy, and pathological phenomena, to prove that these sinuses contribute indeed to the smell, but little or nothing to voice and language as was believed by many physiologists.

† Metzger, *Nervorum Primi Paris Historia.* Argent. 1766. 4to. reprinted in Sandifort's *Thesaurus.* Vol. iii.

Scarpa, *Anatomic. Annotat.* L. ii. tab. i. ii.

‡ This is shewn by pathological dissection and comparative anatomy. Thus in Loder's *Observ. Tumoris Scirrhosi in basi cranii reperti.* Jen. 1779. 4to. is

244. The extreme filaments of the first pair do not terminate in papillæ, like the nerves of touch and taste, but, as it were, deliquesce into the spongy and regular parenchyma of the nasal membrane.

245. The organ of smell is very imperfect and small at birth. The sinuses scarcely exist. Smell consequently takes place but late—as the internal nostrils are gradually evolved, and is more acute in proportion to their size and perfection.*

246. No external sense is so intimately connected

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a case of anosmia, following a compression of the first pair by a scirrhus. We learn, from comparative anatomy, that in the most sagacious mammalia, v. c. elephants, bears, dogs, bisulcous ruminants, hedgehogs, &c. the horizontal plate of the cribriform bone is very large, and perforated by an infinity of small canals, each of which contains a filament of the olfactory nerve.

* While animals of the most acute smell have the nasal organs most extensively evolved, precisely the same holds in regard to some barbarous nations. For instance, in the head of the North American Indian (a leader of his nation, and executed at Philadelphia about 50 years ago), which I have given in the *First Decade of my Collection of the Crania of different Nations, illustrated by nine plates*, the internal nares are of an extraordinary size, so that the middle of the ossa spongiosa, for instance, are inflated into immense bullæ, and the sinuses, first described by Santorini, which are contained in them, larger than I have found them in any other instance.

The nearest to these, in point of magnitude, are the internal nares of the Ethiopians, from among whom I have seen seven heads, now before me, very different from each other, but each possessing a nasal organ much larger than we find it described to be in that nation by Sömmerring, *über die körperl. Verschiedenh. des Negers, &c.* p. 22.

These anatomical observations accord with the accounts given by most respectable travellers concerning the wonderful acuteness of smell possessed by these savages.

Respecting the North American Indians, consult among others Urlsperger, *Nachr. von der Grossbritann. Colonie Salzburg. Emigranten in America.* Vol. i. p. 862.

Respecting the Ethiopians, *Journal des Savans.* 1667. p. 60.

with the sensorium and internal senses, nor possesses such influence over them, as the sense of smell.*

No other is so liable to idiosyncrasies, nor so powerful in exciting and removing syncope.

Nor is any other capable of receiving more delicate and delightful impressions; for which reason, Rousseau very aptly called smell, *the sense of imagination.*†

No sensations can be remembered in so lively a manner as those which are recalled by peculiar odors.‡

NOTE.

An odor must, to be smelt, pass through the nostrils with a stream of air:—a large bottle of ammonia may be kept under the nose for any length of time without affecting it, although the ammonia is all the time flying off.§ Odorous substances placed in the mouth and a very fœtid secretion in the nose or mouth are perceived only when the air is moving through the nostrils and give a stronger impression the more forcibly the air is impelled.

External odors are smelt only when the air passes through the nostrils from without:—after smelling a substance in the usual manner, we in vain attempt to catch the odor a second time by returning the stream of air out again through the nostrils.

* See Alibert on the Medical power of odors, *Mém. de la Soc. Médicale.* T. i. p. 44.

† *Emile.* T. i. p. 367.

‡ Respecting the power of smell over morals and propensities, consult Benj. Rush's *Medical Inquiries and Observations.* Vol. ii. p. 34.

§ Sapid bodies are faintly tasted unless moved along the tongue.

Many substances excite both smell and taste,—a compound sensation to which Dr. Prout, in a very original paper,* conceives the term flavour properly to apply: hence, in catarrh, such substances scarcely give any sensation, as the sense of smell,—one ingredient, is impaired.

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* *Lond. Med. and Physical Journal.* 1812.

SECT. XVI.

OF HEARING.

247. SOUND, which is excited by the collision of elastic bodies and propagated by the air, is perceived by the sense of hearing,* and is first received by the conchiform cartilaginous external ear,† which few of our countrymen have the power of moving.‡ By this it is collected; then conveyed into the meatus auditorius, which is anointed by a bitter cerumen; § (A) and strikes against the *membrana tympani*, which is placed obliquely in a circular furrow of the temporal bone and separates the meatus from the internal ear.

248. Behind this membrane lies the middle portion of the ear,—*the cavity of the tympanum*, whose fundus is directed upwards and inwards.

It contains three ‖ *ossicula auditus:* of which the exterior, or *malleus*, adheres by its manubrium to the membrana tympani, is generally united in the adult

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* Sömmerring, *Abildung des menschlichen Hörorgans.* Franckfurt. 1806. fol.

† B. S. Albinus, *Annotat. Academ.* L. vi. tab. iv.

‡ J. Rhodius ad Scribon. Largum. p. 44 sq.

J. Alb. Fabricius, *De Hominibus ortu non differentibus.* Opuscul. p. 441.

Ch. Collignon, *Miscellaneous Works.* Cambridge. 1786. 4to. p. 25 sq.

§ Consult J. Haygarth, *Med. Obs. and Inquiries.* vol. iv. p. 198 sq.

‖ The existence of a fourth bone (called *Lenticular*), commonly admitted since the time of Franc. Sylvius, I have disproved at length in my Osteology. p. 155 sq. edit. 2. It is wanting in the greater number of perfect examples from adults.

to the circular furrow above mentioned by its spinous process which is directed forwards, and it lodges its round head in the body of the *incus*.

The incus is united to the head of the *stapes* by the extremity of its long process which extends into the cavity of the tympanum.

The stapes, resting its base upon the fenestra ovalis, runs towards the vestibule of the labyrinth, into which, sounds, struck against the membrana tympani, are propagated by the intervention of these three little bones.

249. The Eustachian *tube** runs from the interior of the fauces into the cavity of the tympanum: and the inferior scala of the cochlea has the same direction; the opening of the latter, termed *fenestra rotunda,*† is closed by a peculiar membrane. The true and principal use of each is not sufficiently known.‡

250. In the deepest part of the petrous bone is placed *the internal ear,* consisting of three parts.

First, of the *vestibule,* placed between the other two, into which open not only the fenestra ovalis, but the five orifices of the *semicircular canals* which lie posteriorly, and the superior scala of the *cochlea* which is placed anteriorly.

The vestibule and semicircular canals loosely con-

* Saunders, *Anatomy of the human ear.* Lond. 1806. fol. vol. i. ii.

† Scarpa, *De Structura Fenestræ Rotundæ, &c.* Mutin. 1772. 8vo.

‡ Comparative anatomy renders it most probable that the Eustachian tube is subservient to the action of the membrana tympani. It is found in all red-blooded animals which possess a membrana tympani, but is wanting in fishes which are destitute of this membrane. The different opinions of the moderns respecting its use may be found in Kiel's *Archiv. für die Physiol.* T. ii. p. 18. iii. p. 165. iv. p. 105. viii. p. 67. ix. p. 320.

tain very delicate membranous bags, lately discovered by the celebrated Scarpa. Two of these lie in the vestibule, and three in the semicircular canals.*

251. They, as well as the cavity of the cochlea, contain a very limpid fluid, bearing the name of Cotunni, who shewed it to be absorbed by two canals, by him denominated *aqueducts*† and by the no less illustrious Meckel *diverticula*;‡ the one arises from the vestibule, the other from the inferior scala of the cochlea.

252. The portio mollis of the seventh pair, together with the portio dura (which afterwards runs along the Fallopian *aqueduct*),§ having entered the internal acoustic opening, transmits its medullary filaments into the lower and cribriform part of it.‖ These filaments run to the vestibule and semicircular canals, but especially to the base of the cochlea, where they form a medullary zonula, marked by beautiful plexiform striæ, which pass between the two laminæ of the septum cochleæ.**

253. The oscillatory tremor, which we formerly followed as far as the fenestra ovalis (248), is propagated to the vestibule, where, by means of the water of Cotunni (251), it strikes the auditory nerves distributed among the windings of the labyrinth.

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* Scarpa, *Disquisitiones Anatomicæ de Auditu et Olfactu.* Tab. iv. fig. 5. tab. vii. fig. 3.

† Cotunni, *De Aqueductibus auris Humanæ.* Neap. 1760. 4to.

‡ Ph. Fr. Meckel, *De Labyrinthi auris contentis.* Argen. 1777. 4to.

§ Fallopius, *Observ. Anat.* p. 27 sq. Venet. 1561. 8vo.

‖ Brendel, *Analecta de Concha auris Humanæ.* Gotting. 1747. 4to. The same, *De Auditu in apice conchæ.* IB. EOD. 4to.

** Consult Zinn, *Observ. Botan.* Gotting. 1753. 4to. p. 31 sq. Scarpa, l. c. tab. viii. fig. 1, 2.

254. Besides the muscles of the malleus and stapes,* supposed to be voluntary,† the chorda tympani,‡ which is placed between the handle of the malleus and the longer leg of the incus, is believed to moderate the force of sound that is struck against the membrana tympani and intended to be propagated along the cavity of the tympanum.§ (B)

NOTES.

(A) The cerumen consists, according to Vauquelin, of albumen, which, when burnt, yields soda and phosphate of lime, a colouring matter, and a very bitter inspissated oil strongly resembling the peculiar matter of bile. Cicero, that prodigy of genius, knowledge, and goodness, explains one use of the cerumen :—"Provisum etiam, ut, si qua minima bestiola conaretur irrumpere, in sordibus aurium, tanquam in visco, inhæresceret."|| The same applies to particles of dust. Its extreme bitterness too deters insects from advancing. Its chief purpose is probably to preserve the passage in a fit state for conveying vibrations :—a flute is useless if perfectly dry.

(B) There was an old opinion which appears to my mind

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* B. S. Albinus, *Tabulæ Muscul.* tab. xi. fig. 29.

† Eustachius, *De Auditus Organ.* p. 157.

Caldani, *Institut. Physiol.* 245 sq.

‡ J. Fr. Meckel, *De Quinto pare Nervorum Cerebri.* fig. 1. x. 71.

Leop. M. A. Caldani on the office of the chorda tympani, *Saggi dell' Acad. di Padova.* T. ii.

§ Cotunni, l. c. § lxxxviii. Marherr, *Prælect. in Boerhaavii Inst.* Vol. iii. p. 343.

|| *De Natura Deorum.* L. ii.

perfectly correct,—that the membrana tympani is the principal instrument of distinct hearing;—that its muscles give it various degrees of tension, putting it in unison with the sounds to which we are desirous of attending.* I am conscious that some adjustment within the ear takes place when I direct my attention from one sound to another; some adjustment is demonstrably necessary; the membrana tympani is fitted for this adjustment by its structure and by a supply of muscles; and when it is scaly and rigid, every sound may be heard, but without distinctness.

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* Boerhaave, *Prælect. Acad.* T. iv. p. 360 sq.

SECT. XVII.

OF SIGHT.

255. THE instruments of vision,—the eyes,* are two moveable globes, fixed to the optic nerves whose decussation we formerly noticed (211), as it were to stalks, in such a manner, that their insertion is not exactly opposite the centre of the cornea and iris, but behind this imaginary axis,—rather nearer to the nose.

256. They consist of various coats containing pellucid humours of different degrees of density, so placed that the rays of light can pass from the transparent anterior segment of the bulb to the opposite part of the fundus.

257. The external coat is called *sclerotic*. It is deficient in the centre, and that part is filled up by the *cornea,* which is transparent, lamellated, more or less convex, and projects like the segment of a small globe from one of larger size.†

258. The interior of the sclerotica is lined by the *chorioid,* which abounds in blood-vessels, especially vorticose veins, and is died on each side by a black

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* Sömmerring, *Abbildungen des menschlichen Auges.* Franckfurt. 1801. fol.

† Ad. Jul. Rose, *De Morbis Corneæ ex fabrica ejus declaratis.* Lips. 1767. 4to.

G. H. Gerson, *De Forma Corneæ deque singulari Visus Phænomeno.* Gotting. 1810. 4to.

pigment, adhering, however, but loosely to its concave surface in the form of mucus.*

259. The chorioid contains the internal coat—the *retina*,†—a medullary expansion of the optic nerve which passes through the sclerotica and chorioid,‡ of most beautiful texture,§ and perforated, in the imaginary axis of the eye, between the two principal branches of the central artery,|| by the singular foramen of Sömmerring,** which is surrounded by a yellow edge.†† (A)

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* C. Mundini, in the *Comm. Instit. Bononiens.* T. vii. p. 29. H. F. Elsaesser (præs. G. C. Ch. Storr), *De pigmento oculi Nigro.* Tubing. 1800. 8vo.

† B. S. Albinus, *Annotat. Academ.* L. iii. p. 59 sq. L. iv. p. 75 sq. L. v. p. 66 sq.

‡ Walter, *De Venis Oculi, &c.* Berol. 1778. 4to. tab. i. fig. 2. tab. ii. fig. 2.

§ The extremely beautiful blood-vessels of the retina were first discovered by T. Mery to be visible in a living cat plunged into water. *Mém. de l'Acad. des Sc. de Paris, avant* 1699. T. x. p. 656; and 1704. p. 265.

The most beautifully radiated surface of the retina in the hare is displayed by Zinn in an admirable plate. *Comm. Soc. Scient. Gotting.* T. iv. a. 1754. tab. viii. fig. 3.

By Fontana, in the rabbit. *Sur le vénin de la vipère.* vol. ii. tab. v. fig. 12.

|| A plate accurately representing the course of these branches will be found in the *Œuvres de Mariotte.* p. 527. fig. 1.

** Sömmerring, *De Foramine centrali limbo luteo cincto retinæ humanæ:* in the *Comment. Soc. Reg. Scient. Gottingens.* T. xiii. Ph. Michael Bose, *Journal der Erfindungen in der Natur-und Arzneywiss.* p. xv.

†† As I have discovered this central aperture in the eye of no animal besides man, except the *quadrumana*, the axes of whose eyes are, like the human, parallel to each other, I think its *use* connected with this parallel direction of the eyes, and have endeavoured to explain the connection at large, in my *Handbuch der vergleichenden Anatomie.* p. 547 sq.

As, on the one hand, this direction of the eyes renders one object visible to both at the same time, and therefore more clearly visible; so, on the other, this foramen prevents the inconvenience of too intense a light, if there is a probability that it expands and dilates a little and thus removes the principal focus from the very sensible centre of the retina.

260. The anterior edge of the chorioid is terminated by a cellular belt, called *orbiculus ciliaris,* by which it adheres firmly to a corresponding groove in the sclerotic, and from which two other membranes, viz. the iris and ciliary processes, are expanded in a circular form.

261. The *iris,* (whose posterior surface is lined by a brown pigment and termed *uvea*) lies anteriorly to the ciliary processes, is flat, and washed on all sides by the aqueous humour; narrower towards the nose, broader towards the temples. Its texture is dense and cellular and contains no vestige of muscular fibre. We must regard it, with Zinn,* as a membrane sui generis, and not as a propagation from the chorioid. The anterior surface is differently coloured in different persons, and, during life, counterfeits a flocculent appearance.†

262. The blood-vessels of the iris run chiefly on its anterior surface, and are continued in the fœtus into the *membrana pupillaris,*‡ which begins to open in the centre at the seventh or eighth month of pregnancy,—when the eyes have acquired some degree of size, and when, probably, the elliptic arches of its vessels begin to be gradually retracted into the *inner ring of the iris,* which ring I have never been able to perceive distinctly before that period.

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* *Comment. Soc. Scient. Gotting.* Tom. iv. p. 199.

† On the remarkable mutual relation of the arteries and nerves of the internal parts of the eye and especially of the iris, see Dict. G. Kieser, *De Anamorphosi Oculi.* Gotting. 1804. 4to.

‡ This beautiful membrane was first discovered by Francis Sandys—a celebrated maker of anatomical preparations: it was first described and exhibited in a plate by Ever. J. Wachendorf. *Commerc. Litter. Nor.* 1740. Hebd. 18.

263. The other circular membrane (260) bears the name of *ligamentum* or *corpus ciliare;* and, inclining backwards, lies at a distance from the iris. Its external edge is thick* and adheres to the ciliary circle (260): the internal is thin and adherent to the margin of the capsule of the lens. The brown pigment is copiously diffused over it.

Its anterior surface, lying opposite to the uvea, is striated. The posterior, lying upon the vitreous humour, is beautifully separated into about 70 flocculi, remarkable for an indescribably minute and elegant set of blood-vessels. These flocculi are named *ciliary processes* and their use is still an object of enquiry.†

264. In the bulb of the eye, whose coats we have now described, are contained the humours, of three principal kinds.

The posterior, and by far the greater, part of the globe is filled by the *vitreous* humour, proportionally larger in the human subject, especially after puberty, than in other animals, and so dispersed in innumerable drops throughout the cells of the delicate *hyaloid membrane* that this membranaceo-lymphatic body has the singular appearance of a tremulous jelly.

265. Anteriorly it adheres to, and by means of the *zona ciliaris* surrounds, the capsule containing the *crystalline lens,* immediately around which lies the water of Morgagni.

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* The ciliary canal, discovered by Fel. Fontana, (*sur le vénin de la vipère.* vol. ii. tab. vii. fig. 8, 9, 10,) and afterwards described more accurately by Adolp. Murray, (*nov. act. Upsaliens.* vol. iii.) runs, in bisulcous animals, along this thick edge.

† Consult among others Brandis, *Pathologie.* p. 253.

The lens itself is very pellucid and cellular, but so much more dense than the vitreous humour that in the hand it seems like a very tenacious, although an amazingly clear, gluten. Its nucleus is more dense than the exterior lamellæ. These may, by management, be reduced into extremely delicate fibres, converging from the circumference to the centre.*

In an adult man the lens is proportionally smaller than in quadruped mammalia; also less convex, especially on its posterior surface.

266. The remaining space of the eye is filled by the *aqueous humour*, which is very limpid, and divided by the iris into two *chambers*:—the anterior and larger separating the cornea and iris; and the posterior, in which the uvea lies towards the corpus ciliare, so small, as scarcely believed by some to exist.

267. These most valuable parts are defended from injuries both by the depth of their situation in the orbits and by the valvular coverings of the eye-lids.

In the duplicature of the *palpebræ*, lie the *sebaceous follicles* of Meibomius,† thickly distributed; and their edges are fringed by a triple or quadruple series of *cilia*:‡ the cartilaginous *tarsi* serve for their support and expansion, and also facilitate their motion upon the eye-ball.

Above the eye-lids, to use the language of Cicero, the skin is covered by the *supercilia*, which preserve the eyes from the sweat that flows from the head and

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* Th. Young, *Philos. Trans.* 1793. tab. xx. fig. 2, 3.
Dav. Hosack, ib. 1794. tab. xvii. fig. 4.
J. C. Reil, *De lentis crystallinæ structura fibrosa.* Hal. 1794. 8vo.

† H. Meibomius, *De vasis Palpebrarum novis ep.* Helmst. 1666. 4to.

‡ B. S. Albinus, *Annotat. Academ.* L. iii. tab. iii. fig. 4.

forehead, and in some measure screen them from too strong a light.

268. To lubricate the eyes, to preserve their brightness, and to wash away foreign matters, is the office of the *tears*. Their chief source is a conglomerate gland placed in the upper and exterior part of the orbit. It has numerous but very fine excretory ducts, which are said to discharge about two ounces of tears upon each eye during the twenty-four hours: the tears are afterwards absorbed by the puncta lachrymalia, the function of which may, in a certain sense, be compared to that of the lacteals in the villous coat of the small intestines; from the puncta they are conveyed through the snails' horns, as they are called, into the lachrymal sac, and thence pass into the lower meatus of the nostrils.* (A)

269. Thus much it was necessary to premise upon the structure of the organ of vision. We now come to the function of the organ,—to the explanation of vision.

Rays of light falling upon the cornea at an angle more acute than forty-eight degrees, pass through it, and, from both its density and figure, are considerably refracted towards the axis of the eye. On entering the aqueous humour they experience rather a less degree of refraction.

Those rays which penetrate the pupil and are received by the lens, are still more refracted on account of the greater density of this medium.

The less density of the vitreous humour prevents the focus of rays from being too small, but allows it to fall elongated upon the retina and exhibit the image

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* J. Chr. Rosenmüller, *Organa Lachrymalium Partiumque Externarum Oculi Humani Descriptio Anatomica.* Lips. 1797. 4to.

of objects, inverse indeed necessarily from the laws of light.

270. The *focus* which, in this mode, falls upon the retina, is considered acute, not absolutely but relatively, on account of the different refrangibility of colours; but the latitude arising from this aberration of the rays is so small that it not only does not obscure the clearness of vision in any perceptible degree, but is the source of many advantages.*

271. The celebrated question—why we behold objects erect, while their image is painted inversely upon the retina,† may be easily answered, by considering that objects are called inverse relatively only to those which appear erect.

Now, since the images of all objects and of our own bodies are painted on the retina, each in its relative situation, this relative situation must correspond as exactly as if they were viewed erect, so that the mind (to which a sensation excited by the image and not the image itself is communicated) is preserved from all danger of error.

272. Since many conditions are required for distinct vision, the Creator has wonderfully ordered the functions of these organs.

A sufficient, but, at the same time, a definite, quantity of light, not too intense for distinct vision, is provided in two modes:—First, according to the greater or less intensity of the rays, a greater or less number

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* Nev. Maskelyne, *Attempt to explain a Difficulty in the Theory of Vision, depending on the different Refrangibility of Light. Philosophical Transactions.* Vol. lxxix. p. 256.

† J. H. Voight, *Magazin für Physik und Naturgeschiechte.* T. v. P. iii. p. 143.

of them pass to the lens;—Secondly, that portion which is superabundant and injurious to vision, is absorbed.

The first is effected by the motion of the iris; the second, by the pigmentum nigrum.

273. The iris is endowed with sufficient mobility to accommodate itself to the intensity and distance of light, that, when exposed to a strong light or to near objects it may expand itself and contract the pupil, but when to a weaker light or more remote objects it may contract itself and dilate that opening.* Physiologists have given different explanations of this motion. Some ascribe it to the varied impulse of blood into its vessels; others to contraction of its imaginary muscular fibres. I have shewn, in a particular treatise, that both these circumstances are impossible, and that its proximate cause may be sought for with more probability and reason in the vita propria of the iris (42); the more remote cause, as we formerly hinted (56), can be solely the reaction of the sensorium.†

274. The function of the dark pigment, so frequently mentioned, (258, 261, 263,) viz. to absorb the superfluous rays, and its importance to the perfection of vision, are demonstrated, among other modes, by the dissection of different kinds of animals, and by the diseased condition of Albinos, whose eyes are very tender and impatient of light from the absence of this pigment.‡

* Zinn, *De Motu Uveæ*. 1757. in the *Comment. Societ. Scient. Gotting*. T. i. Fel. Fontana, *Dei Moti dell' Iride.* Lucca. 1765. 8vo.

† For other explanations consult Troxler in Himly's *Ophthalmol. Biblioth.* T. i. P. ii. p. 21.

‡ I have spoken of Albinos at large in my work *De Generis Humani Varietate Nativa*, ed. 3. p. 274; and in my dissertation *De Oculis Leucæthiopum*.

275. The focus of the refracted rays must fall exactly on the retina, so that the point of vision be neither produced beyond it nor shortened enough to strike on the vitreous body.

The latter defect exists in short-sighted persons, from the too great convexity of the cornea or gibbosity of the lens.

The former is the defect of long-sighted persons, in whom there is the opposite conformation of parts.

276. Since a perfect and sound eye beholds near and remote objects with equal distinctness, it must of necessity be supplied with appropriate powers of accommodation.* That these internal changes of the eye are chiefly accomplished by the pressure of the straight muscles of the ball, I am clearly convinced, from this among other arguments,—that in the Greenland whale—an amphibious animal which must see in media of different densities, nature has most accurately provided for it, in the remarkable structure and obsequious flexibility of the sclerotica.† (C)

277. During the waking state, the eyes are perpetually, although insensibly, agitated, and directed towards the axes of objects, by these muscles.

For, although the whole of the retina is sensible, it is not all equally calculated to receive the images of objects.

In the first place, the true axis of the human ‡ eye,

* H. W. Math. Olbers, *De Oculi Mutationibus Internis.* Gotting. 1780. 4to. Ever. Home, *Philos. Trans.* 1795. p. 1.

† *Comment. Societ. Scient. Gottingens.* T. vii. p. 62. fig. ii. f. g. h.

‡ I say the human eye; for in some animals now before me, the seal and porcupine, for instance, the true and imaginary axis are the same, the optic nerve lying exactly opposite the centre of the cornea and pupil.

where the optic nerve enters, is proved, by the well-known experiment of Mariotte,* to be nearly insensible to light.(D) The *principal focus* of the rest of the retina, which must be considered as the chief instrument of distinct vision, falls upon an imaginary axis of the globe, corresponding with the axis of the cornea and of the whole eye. This, however, as Kaestner observes in opposition to Boerhaave, is not to be understood as if only one point of an object could be seen distinctly at once, while the eye is fixed, and that, to behold another point, the axis of the eye must be changed; for the sensation of a complete object is simple and complete.†

278. The habit of directing the axes of the eyes rapidly towards objects is acquired by practice. This is proved by the example of persons who were born blind but recovered their sight after puberty; ‡ and of children, who seldom acquire this facility of motion before the third month.

279. To habit we must ascribe also the circumstance of beholding an object singly, although we have two eyes.§ For infants at first see double, and the double vision which occasionally remains after certain diseases of the eyes may be removed by practice and experience.(E)

280. The combined power of the two eyes does not

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* Troxler speaks of this at large, l. c. T. ii. P. ii, p. 1.

† *In Optica Quædam* Boerhaavii et Halleri *Commentatur* Abr. Gotth. Kaestner. Lips. 1785. 8vo. p. 7.

‡ See Giov. Bartolozzi, *sopra una cieca nata guarita.* Verona. 1781. 8vo. p. 99 sq.

§ W. C. Wells, *Essay upon single vision with two eyes.* Lond. 1792. 8vo.

exceed, according to Jurin, that of each, by more than one thirteenth part.

It is needless to add, what the celebrated painter, Leonardo da Vinci, long since remarked,—that in viewing distant objects, it is preferable to employ but one eye.* (F)

281. Sight can never occur unless the angle of vision exceeds 34 *seconds*. This was proved by the very beautiful experiments of the acute Tob. Mayer, who formerly was one of our number. And he demonstrated the great excellence of the human sight, by shewing that this still remained the limit of vision under any light,—under the splendor of the meridian sun and the faint light of a lantern; so that vision remains almost equally clear although the light be considerably diminished.†

282. We may hence infer the prodigious minuteness of the images of objects projected upon the retina,‡ and nevertheless impressed so forcibly upon it, that, under certain circumstances, their vestiges remain, after the removal of the objects from before the eye. §

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* Consult Lambert, *sur la partie photometrique de l'art du peintre* in the *Mém. de l'Acad. des Sciences de Berlin.* 1768. p. 80 sq.

† Tob. Mayer, *Experimenta circa visus aciem,* in the *Commentar. Soc. Scient. Gottingen.* T. iv.

‡ De la Hire, *Accidens de la vue.* p. 375.

§ Gassendi, *Vita* Peireskii. p. 175 sq. Hague. 1655. 4to.

Franklin, *Letters on Philosophical Subjects,* at the end of his *Expts. on Electricity.* Lond. 1769. 4to. p. 469 sq.

Rob. War. Darwin, *Experimenta nova de spectris s. imaginibus ocularibus, quæ objectis lucidioribus antea visis, in oculo clauso vel averso percipiuntur.* Lugd. Bat. 1785. 4to.

Er. Darwin, *Zoonomia.* T. i.

C. Himly, *Biblioth. Ophthalmolog.* T. i. P. ii. p. i.

NOTES.

(A) A delicate transparent membrane has been discovered by Dr. Jacob of Dublin, between the retina and chorioid, and adhering to both.*

(B) I am not satisfied with any account which I have hitherto seen, of the function of the eyelids with respect to the tears. Perhaps the tears pass over the ball of the eye as low as the edge of the superior tarsus, which is so applied to the ball as not ordinarily to allow of their ready escape under it.† As the lids (the under has but little motion) cover the eye during sleep and their fine inner edges meet, the whole of the ball is at this time readily preserved moist. But when the eyes are open, the front of the eye between the lids would not be moistened unless the upper tarsus occasionally descended with the fluid contained behind it. The fluid thus brought upon the front of the eye, trickles down, after winking, by its gravity as far as the inferior tarsus, which also occasionally ascending a little, raises it somewhat. Winking thus preserves the front of the eye constantly moist during the waking state.

It may be also observed that when the tarsi approximate, as they drive before them the moisture of the front of the eye-ball, they quite inundate the puncta lachrymalia, by which circumstance the puncta are of course enabled to carry off a large quantity of the secretion, and ordinarily to prevent its overflow, which would occur at the centre of the lower tarsus. During sleep the puncta are not so copiously supplied, as they have only the same share of tears as the eye in general; and there is less occasion for it, because the removal of the stimulus of air and light by the closure of the eyelids, lessens the secretion.

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* *Phil. Trans.* 1819.

† The object of this firm application of the tarsi to the eye must be the exclusion of foreign matters from the orbit.

M. Majendie has found the matter of the tarsal or Meibomian glands to be not sebaceous but albuminous, and soluble in the tears: hence we discover why, during sleep, it accumulates on the tarsi;—because its solvent, the tears, are not sufficiently abundant to remove it.

(C) In Albino animals, whether the rabbit, pigeon, or mouse, the sclerotic and chorioid are nearly transparent, the latter losing its blood after death, and the image formed upon the retina may be readily seen without removing a portion of the sclerotic. From observations of this kind M. Majendie has declared that whether the eye be presented to a neighbouring or to a distant object, the image upon the retina is equally distinct, and therefore that all the explanations of this circumstance which have been hitherto given, founded on changes which can occur only during life, fall to the ground, whether founded on pressure of the ball by the recti muscles, motion of the crystalline, contraction of the crystalline or ciliary processes, &c. The iris, however, dilates when we look at a distant, and contracts when at a near, object; as may be distinctly observed by holding up a finger and desiring a person to look alternately at it and at a distant object which stands in the same line. We are conscious of this adjustment of the iris: we move the muscle (if it may be so called) voluntarily, and the act is painful if quickly repeated.

M. Majendie also discovered that the escape of a little of the aqueous or vitreous humour, or the total removal of the former or of the cornea, impaired the distinctness of the image; the total removal of the aqueous humour or of the crystalline also increased the size of the image; the removal of the humours prevented the formation of any image; an increase produced in the pupil by a circular incision of the iris produced an increase of the image.*

(D) Mariotte's experiment was to make two spots upon a wall, to fix the right eye upon the left spot, the other being closed,

* *Précis Elémentaire de Physiologie.* T. i. p. 61 sq.

and gradually to retire till the right spot was no longer distinguishable. This is said to occur when its image falls upon the centre of the optic nerve. I should suppose that it disappeared at a certain distance, merely because too minute for detection when the eye was being directed to the other spot. For the same reason, in Picard's variation of this experiment, by placing an object between the eye and the spots, so that it shall appear double and one image of it cover one spot completely when one eye is closed, the disappearance of the spots at the time the intervening object is looked at, probably arises from the one spot being covered by it, as in truth only one eye is here employed although both are open, and from the other spot being too distant to be visible when the attention is directed to the intervening object.

(E) The notion of our originally seeing objects upside-down, double, and all as at the same distance, is satisfactorily refuted by Dr. Spurzheim. The organs of sight, and all the others of sense, present, if perfect, a perfect impression to the inward senses,—the faculties for judging of form, distance, colour, tune, &c. and nothing farther. These do the rest. My reader must consult Dr. Spurzheim, and particularly Mr. Coombe.

(F) Although we certainly use both eyes to look generally at objects before us (those on each side can of course be seen by the eye of the same side only), yet when we fix attentively on an object, we employ but one. This at least is my own case. If I hold up a finger, and look at distant objects, it appears double, and if I then look at it, I of course see it single, and the figure now seen is, in my case, that which was previously seen with the right eye: no difference occurs in it, if now the left eye is closed.* The greater facility of threading a needle, when both are open, probably arises from the advantage of increasing the field of vision while one eye is fixed steadily upon the aperture.

* See also Spurzheim. l. c. p. 299.

SECT. XVIII.

OF THE VOLUNTARY MOTIONS.

283. We have seen that the nerves perform two offices (220)—the one of feeling, the other of moving. The former we have already considered; we shall now say something with respect to the latter.

284. All the motions of the body may be divided into voluntary and involuntary.

The pulsation of the heart, and the peristaltic motion of the intestines and other viscera, are commonly adduced as instances of involuntary motion.

The action of by far the greater number of the other muscles is voluntary.

Respiration, sneezing, the tension of the membrana tympani, the action of the cremaster, are regarded by some as belonging to the former class; by others, to the latter; and by others, as of a mixed nature.

285. If this division is narrowly examined, it will be found embarrassed by so many difficulties that the limits of each class cannot well be determined.

For, on the one hand, few functions can be termed truly involuntary, especially if we consider the connection of the imagination and passions with the will.

Again, on the other hand, there are few voluntary motions that may not be rendered involuntary by the force of habit, whose influence upon our animal motions is immense.

286. Of the latter description are those muscular motions which, although generally voluntary, take place, under certain circumstances, without the knowledge of the mind or even in opposition to its endeavours.

Thus we wink *involuntarily,* if a friend suddenly approaches his finger to one of our eyes, though it does not come in contact: the ring finger generally bends if we bend the little finger.

We often *unconsciously* move our limbs even while sleeping soundly.

On the contrary, some muscles which are almost always obedient to the will, occasionally cease to be so: an instance of this exists in the difficulty which we experience in attempting to move the hand and foot of the *same* side in *different* directions, and in all those motions which, although voluntary and perfectly easy if produced separately, are found very difficult if attempted together.*

287. Among those motions which are supposed to be perfectly involuntary, no one is free from exception, as far as we know, excepting the spasms of the uterus during labour.†

With respect to the motion of the heart, we have the indubitable testimony of Baynard and Cheyne, that they saw the famous English officer who could stop the motion of his heart and arteries at pleasure.‡

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* Consult Winslow, *Mém. de l'Ac. des Sciences de Paris.* 1739.

† These are partly voluntary in some warm-blooded animals, as is shewn in birds when sitting, which, if deprived of their eggs, are well known to lay others in succession.

‡ Cheyne, *Treatise on Nervous Diseases,* p. 307 sq.

There is no question that the pulsation of the heart and arteries may be accelerated or retarded by the varied state of respiration.*

Rumination shews that the action of the stomach may be voluntary, and I myself once distinctly found it so, in a man who had the power of ruminating.

Although the motion of the iris is involuntary in most persons, I have been credibly informed that some have been able, by a considerable effort, to subject it to the will and contract the pupil in a weak light.

So numerous are the motions commonly called involuntary which become voluntary in some particular individuals, especially if aided by attention and liveliness of imagination.†

Thus I have seen some able to produce at any time a spasmodic horripilation of the skin, by representing some unpleasant sensation to their imagination.

Others have had the power of exciting local sweat in the hands, &c.‡ (A)

288. This may perhaps be explained on the principle of sensorial reaction, (56) which may be produced by imagination—a mental stimulus, as easily as by a corporeal stimulus acting upon the sensorium. (52) Many phenomena accord admirably with this explanation; v. c. the various causes of the erection of the penis, and of the flow of saliva.

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* See Sam. Lath. Mitchill, *On the gaseous oxyd of azote*, &c. New York 1795. 12mo. p. 26.

Also Leop. Caldani, *Memorie della accademia di Mantova*. T. i. 1795. p. 118.

† See the *Rapport des Commissaires chargés par le Roy de l'examen du magnétisme animal*, written by J. Sylv. Bailly, a man worthy of a better fate. Paris, 1784. 4to. p. 16.

‡ See v. c. T. Bartholin, *Act. Hafniens.* 1676. vol. iv. p. 191.

289. The voluntary motions are the distinguishing characteristics of the animal from the vegetable kingdom. For no plant has been discovered procuring for itself food by means of voluntary motion; nor any animal incapable of locomotion, or at least of procuring sustenance by the voluntary motion of individual members.

290. In ourselves, these motions afford a striking proof of the intimate harmony that subsists between the body and the mind, and is demonstrated in the rapid and various motions of the fingers of a good performer on the harp, and of the vocal organs whenever we speak.*

NOTE.

(A) Those muscles, I conceive, are called voluntary, which we ordinarily have the power of directly contracting: those involuntary, which we have not ordinarily the power of directly contracting. These two definitions appear to me unexceptionable.

The latter does not contradict what is unquestionably true,—that we can indirectly affect involuntary muscles, as the heart or stomach, by thinking of certain objects, and thus exciting certain emotions; nor does the former contradict another truth,—that voluntary muscles often contract without or against our will. And this leads me to remark that the respiratory muscles deserve the epithet voluntary as much as any in the body, for we

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* A person playing on the harp, dancing, and singing, at the same time, exercises about three hundred muscles at once. G. Ent, *Animadv.* in Thrustoni *diatribam.* p. 130.

directly contract them: we feel an uneasy sensation in the chest from the retardation which occurs to the blood, and we inspire to remove it; the uneasiness being removed, our effort ceases, and expiration spontaneously ensues. It is true that the uneasiness is so great that we are forced to inspire, and that respiration continues while we are asleep. But the same is true of all voluntary muscles:—if you irritate any part of a person asleep, an effort of some kind is made to remove it; and if you cause strong pain or titillation in a person awake, he will be compelled, whatever restraint he may attempt upon himself, to make an effort to remove it by motion of some part, as forcibly as he is compelled to remove the uneasiness in the chest by inspiration,* and while history records examples of men standing motionless in the midst of fire till they were consumed, we read of suicides so determined as to have accomplished their purpose by merely holding their breath, when deprived of access to instruments of destruction.

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* Dr. Wilson Phillip, *Edinb. Med. and Surg. Journal.* 1809.

SECT. XIX.

OF MUSCULAR MOTION.

291. THE immediate organs of motion, by far the most numerous in the body, are the *muscles*, which form the greatest bulk among all the similar parts.

292. They abound in azote more than other animal parts; and the departure of this principle from its combination with hydrogen and carbon which exists during health, entirely converts them, under a particular morbid affection * and after death,† into an adipocerous substance, resembling soap or spermacete.

293. The muscles are distinguished from other similar parts by two characteristic features, the one derived from their structure, the other from their singular vital powers.

294. This fleshy structure is so formed of moving fibres, *sui generis* and of a very faint red colour, that every muscle may be resolved into fibrous bands, these into bundles of fibres, and these again into very fine fleshy fibrils. (A)

295. Every muscle possesses a covering of cellular

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* For instance, in Elephantiasis. Consult Ph. Gabr. Hensler, *Vom abendländischen Ausfatze im Mittelalter.* p. 316. Accurately described examples of similar changes in other affections, may be found in *Hedendaagsche Letter-Oefeningen.* T. iv. P. ii. p. 45; and in the *Mémoires de Mathématique, &c. presentés à l'Acad. des Sciences de Paris.* T. vii. p. 301.

† See Thouret, *Journal de Physique.* T. xxxviii. p. 255. G. Sm. Gibbes, *Philos. Trans.* 1794. p. 169.

membrane,* which is so interwoven with its substance as to surround the bands, the bundles, and even each particular fibril.

296. Every part of the muscles is amply supplied with blood-vessels and nervous threads. The latter appear to deliquesce into an invisible pulp and unite intimately with the muscular fibres: the former are so interwoven with the fibres, that the whole muscle is red and acquires its own paleness (294) only by being washed.

297. Most muscles terminate in tendons,† which are fibrous ‡ parts, but so different in colour, texture, elasticity, &c. as to be readily distinguished from muscles: thus disproving the opinion of some,—that the tendinous fibres originate from the muscular. This error arose chiefly from the circumstance of the muscles of infants containing a greater number of fleshy fibres, in proportion to the tendinous, than those of the adult.

298. The other exclusive character of muscles (293) is the *irritability* of Haller, § the notion of which, and its difference from contractility, we formerly explained (41), but shall now prosecute farther.

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* See Ad. Murray, *De Fascia Lata.* Upsal. 1777. 4to.

† See Fourcroy, *Mémoires de l'Academie des Sciences de Paris.* 1785. p. 392; and 1786. p. 38.

‡ Albinus, *Annotat. Academ.* L. iv. Tab. v. fig. 2.

§ I thus distinguish it, not because the luminary of the Gottingen school first discovered it, for he repeatedly bestowed praises upon the opinions entertained with regard to it by his predecessors from the time of Glisson, but because he first investigated it as it deserved, illustrated it, enlarged the knowledge of it by numerous living dissections, and demonstrated the great power and influence of the doctrine, thus remodelled, upon the animal economy. I have also another reason, viz. to distinguish it from the irritability of the truly meritorious Gaubius, who applied the same term to the morbid sensibility of the living solid.

299. This irritability, muscular power, or *vis insita*, is bestowed upon all muscles, but in different degrees.*

300. The highest order are the hollow muscles which perform the vital and natural functions, and especially the heart, (124) whose internal surface enjoys a very lively and permanent irritability.

Next to the heart follows the intestinal canal, particularly the small intestines, which, in warm-blooded animals, contract after the heart has ceased to show signs of irritability.

Next the stomach.

Then the urinary bladder, &c.

Among the other muscles, the respiratory, v. c. the diaphragm, the intercostals, and triangularis sterni, are remarkable for their irritability.

Then follow the remaining muscles.

Less, but still however some, exists in the arteries. (128)

Also in the venous trunks contained in the thorax. (95)

Still less, if it deserve the name of irritability, in the other blood vessels. (132)

301. Haller, the great arbitrator in the doctrine of irritability, has ascribed it improperly (40, 5807), we think, to some parts possessed indeed of *contractility*

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* See Haller on the irritable parts of the human body, *Commentar. Soc. Sc. Gotting.* T. ii. and *Nov. Commentar. Gotting.* T. iv.

Among innumerable other writers on the same subject, suffice it to quote the following :—

Zimmerman, *De irritabilitate.* Gott. 1751. 4to.

Oeder, on the same. Copenhagen. 1752. 4to.

J. Eberh. Andreæ, on the same. (Præs. Ph. Fr. Gmelin,) Tubing. 1758. 4to.

Some others have been already mentioned, as well as three entire Collections of Writers (p. 182.)

but in which I have never been able to detect genuine irritability.

Such are the lacteals, glands, gall-bladder, uterus, the dartos, and the penis. (B)

And others, with no less impropriety, bestow it upon the iris, the external surface of the lungs, &c. in which it no more exists than in the cellular membrane and those parts which are composed of it,—the common integuments, membranes of the brain, pleura, peritonæum, periosteum, medullary membrane, tendons, aponeuroses, &c. or in the proper parenchyma of the viscera, (20)—of the liver, spleen, kidneys, secundines, the brain, and the rest of the nervous system, every one of which parts is destitute alike of muscular fibre and of what is peculiar to it,—irritability.

302. As we find muscular irritability sometimes confounded with the *contractility* of the mucous web; so, on the other hand, some eminent men, particularly in modern times, have attributed it to the *nervous energy*.*

Now, although we cannot deny the influence of the nerves upon the muscles, most strikingly shewn of late (225) by the experiments of the celebrated Galvani and others, and although no muscular fibril, however minute, can be found absolutely destitute of nervous pulp, we are not on this account to assert that irrita-

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* To this point chiefly relate the celebrated disputes respecting the influence of nerves upon the motion of the heart, and the modus operandi of opium upon the heart and nerves.

Consult, besides other authors already quoted,

Rob. Whytt, *Essay on the vital and other involuntary motions of animals.* Edinb. 1751. 8vo.; and more at large in his Works. ib. 1768. 4to.

J. Aug. Unzer, *erste Gründe einer Physiologie der eigentlichen thierischen Natur thierischer Körper.* Leipzig. 1771. 8vo.

bility is not a power *sui generis*, as clearly different from the nervous energy as from contractility. For parts not muscular are not irritable, however abundantly they may be supplied with nerves, as the corium, the numerous nervous viscera; and the muscular texture alone exhibits the genuine phenomena of irritability. So that from the weight of these united arguments, to omit many others, it appears more just to assign these phenomena to the muscular fibre alone, than to ascribe them to the nerves which are common to so many other parts but do not in these excite the faintest sign of irritability. We say nothing of many weighty arguments derived, for instance, from the facts,—that no proportion exists between the degree of irritability and the number of nerves in any part,—that one description of vital powers is often very energetic, while the other is languid in the same individual, according to national, morbid, or more especially to sexual variety, &c. (C)

303. The nerves exert their influence upon the muscles, as *remote* or *exciting* causes of their action, but by no means as the *proximate* or *efficient*, which is the inherent irritability of the muscles.

The passions, v. c. act upon the sensorium, this upon the nerves of the heart, so as to excite its irritability, which produces palpitation and other anomalous motions.

The will acts upon the sensorium, this reacts upon the nerves of the arm, which excite muscular motion, as remote causes; but the proximate cause is the irritability of the muscles themselves.

304. With this distinction of the two causes of muscular motion, the result of those experiments exactly

correspond which have been so frequently made by dividing or tying the nerves.* Paralysis ensued, but irritability continued vigorous for a length of time afterwards.

There have been cases where one limb was motionless from paralysis but retained its sensibility, while the other was insensible but still capable of motion.† Some persons have had great pain in paralytic parts.‡

305. The true efficacy of the blood, so copiously afforded to muscles, (296) in promoting their action, is not clearly ascertained.

In the Stenonian experiment,§ indeed, paralysis of the hind legs commonly follows the application of a ligature upon the abdominal aorta.‖ (D)

But after all, we are confirmed in the opinion formerly mentioned (125),—that the action of what are commonly called voluntary muscles depends less than that of the heart upon the afflux of blood to the moving fibres; and on the contrary, more than it, upon the influence of the nerves which excite their irritability.

306. Besides these inherent powers common to all muscles, there are some peculiar and adventitious, arising from figure, situation, &c. and answering their object with perfect accuracy.

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* J. H. v. Brunn, *Experimenta circa Ligaturas Nervorum in vivis animalibus instituta.* Gotting. 1753. 4to.

† v. J. Stewart, *De Systematis Nervosi Officiis.* Edinb. 8vo.

‡ C. H. Pfaff, *über Thierische Elektricität und Reizbarkeit.* Leipzig. 1795. 8vo. p. 263.

§ Stenonis, *Elementor. Myologiæ spec.* Florent. 1667. 4to. p. 86.

‖ See Courten, *Philos. Trans.* No. 335. p. 500; and Haller, *Comment. Soc. Sc. Gotting.* T. iv. p. 293.

307. From this circumstance, the muscles in general are divided into hollow and solid. The former, as we have seen, not directly subject to the will, belong more to the vital and natural functions and are consequently not to be considered at present, while we are speaking of the voluntary muscles, which belong to the order of animal functions.

308. Among the latter, also, there is much variety. For, not to allude to difference of size, there is great diversity in the disposition of their bands and fasciculi, the direction of their fibres, the proportion of the fleshy to the tendinous part, their course, mode of insertion, &c.

309. The greatest number are long, and their fleshy bellies terminate at each extremity in tendinous chords, inert, and destitute of irritability, and fixed to the bones, which they move in the manner of levers.

310. While a very few muscles are destitute of tendons, such as the latissimus colli, an equally small number are not inserted into bones, such are the cremaster, as we generally find it, the azygos uvulæ, most of the muscles of the eye, &c.

311. The muscles endowed with those common (298 sq.) and peculiar (306 sq.) powers, are thus prepared to perform their actions, which also may be divided into common and peculiar.

312. A property common to all muscles, and the immediate consequence of their irritability, is to become shorter, more rigid, and generally unequal, and, as it were, angular, during contraction.

To attempt, with J. and D. Bernouilli and other mathematical physicians, to reduce this diminution to a general admeasurement, is rendered impossible, by the great difference, among other causes, between the hollow and solid muscles in this respect, and between the solid muscles themselves, v. c. between straight muscles (such as the intercostals) and sphincters.

313. The peculiar actions of muscles (311) correspond with their peculiar powers, and consequently vary so much as to be referrible to no general laws.

To cite one instance out of many, that action of certain muscles is peculiar and anomalous which seldom occurs alone but nearly always *subsequently* to, or *simultaneously* with, the action of some of a different order. Such is that of the lumbricales, when, during rapid motions of the fingers, they follow the action of other muscles of the metacarpus and forearm; and of the lateral recti muscles of the eyes, either adducens of which seldom acts, unless simultaneously with the abducens of the other eye.

The commonly received law—that a muscle during its contraction draws the more moveable point of insertion to the more fixed, must be considered, as Winslow wisely remarks,* perfectly relative and subject to various limitations. Thus, for example, sometimes the one point, and sometimes the other, may be the more moveable; accordingly as the united action of many different muscles may render the opposite more fixed.

And, on the other hand, although the action of the flexors is generally so much stronger than that of their antagonists—the extensors, that, when the body is at rest, the arms, fingers, &c. are a little bent, this does

* *Mém. de l'Acad. des Scienc. de Paris.* 1720.

not so much depend upon the strength of the contraction of the flexors, as upon the voluntary relaxation of the extensors for our own relief.

314. Every muscle has moreover a peculiar *mechanism*,* adapted to the individual motions for which it is intended. Besides the determinate figure of each, many other kinds of assistance are afforded to their peculiar motions. The *bursæ mucosæ*, chiefly found among the muscles of the extremities; the annular ligaments by which some are surrounded; the fat in which most are imbedded; the lymphatic vapour around each; and, above all, the conformation of the sceleton, chiefly in regard to apophyses, condyles, and articulations; nay, even whole bones, v. c. the patella, the pisiform of the carpus, and the sesamoid bones;† are destined solely to facilitate the actions of certain muscles.

315. In this mode is compensated, or at least diminished, that inevitable loss of power which necessarily takes place from the conformation and stature of the whole system, in which, from the acute angle at which some muscles are inserted or the proximity of their insertion to the centre of motion, much of that power is lost which would have existed, if their insertion had been more remote or at a more obtuse angle.‡

316. The human body, possessing about 450 muscles,

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* P. J. Barthez, *Nouvelle Méchanique des Mouvemens de l'Homme et des Animaux*. Carcass. 1798. 4to.

† Hence, of all animals which I have dissected, the mole is supplied with the most remarkable apparatus of sesamoid bones; its anterior palmated feet, with which it digs, have many of these bones, which greatly facilitate the action of the brachial muscles.

‡ Gilb. Blane, *on Muscular Motion*. p. 51.

or upwards, according to sexual or individual variety, is thus furnished with a double advantage,—with an extreme agility of motion in particular parts and throughout the whole, and with a surprising degree of strength and endurance of labour. Both these are accomplished partly by the perfection of the muscles, which, like the perfection of ossification, takes place at manhood; and partly by habit and practice, the former of which in affording strength and agility to the muscles, is demonstrated in rope-dancers, leapers, runners, wrestlers, porters, savages, and the examples of ancient nations.*

NOTES.

(A) Mr. Bauer discovers muscular fibres to be chains of globules;† and it is suggested that they may be constructed by the globules of fibrine arranging themselves in lines.

(B) Irritability is the power of contracting upon the application of a stimulus, and ceases with life. It comprehends animal and organic contractility, (See Note to Sect. VI.) and we must suppose the lacteals, vessels of glands, gall bladder, and dartos to be possessed of it: the uterus will hereafter be shewn positively to have muscular fibres, and their existence will be rendered probable in the corpora cavernosa of the human penis.‡

(C) See Note F. Sect. XII.

(D) This paralysis does not show the irritability of the

* I have treated on this point at large, in the *Medic. Biblioth.* Vol. ii. p. 407.

† *Phil. Trans.* 1818.

‡ Mr. Shaw has written a very excellent paper against the muscularity of the urethra. *Med. Chir. Trans.* Vol. x.

muscles to be impaired; they would doubtless contract immediately after this experiment, upon the application of a stimulus, as readily as they do after apoplexy. The ligatures act immediately by depriving the nerves of the power of stimulating them; for a supply of arterial blood is necessary to the function of the nervous system,* and the ligature of the abdominal aorta cuts this off from the lower part of the spinal marrow and what originate from it,—the nerves of the hind legs. If venous blood is sent to the brain, death ensues, and the function of any part is arrested by forcing venous blood into its arteries.†

Another source of paralysis must ultimately arise,—the loss of irritability from the want of circulation in the muscle.

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* Le Gallois, *Sur le Principe de la Vie.*

† Bichat, *Récherches Physiologiques.*

SECT. XX.

OF SLEEP.

317. The faculties both of feeling and motion, possessed by the nervous system whose history we have thus pursued, are so fatigued by their exertions in the day, that rest is necessary during the night to recruit them by means of *sleep* *—the image of death.

318. Sleep is a periodical function, by which the intercourse of the mind and body is suspended, and whose phenomena, now to be traced, correspond very aptly with the supposition of a nervous fluid.

319 Besides other precursors of sleep, may be enumerated a gradually increasing dulness of the external senses, and a relaxation of most, especially of the long, voluntary muscles; a congestion of venous blood about the heart, and relief afforded by yawning to the uneasy sensation thus produced; lastly, a curious kind of short delirium at the moment when sleep is all but present.†

320. The phenomena of sleep, therefore, amount to this,—that the animal functions are suspended, and all the rest proceed more slowly and inactively. For the pulse is slower, the animal heat, cæteris paribus, diminished, perspiration more sparing, digestion imperfect,

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* Consult, among authors hereafter to be recommended, Er. Darwin, *Zoonomia.* T. i. Sect. xviii.

† De Pauw has some singular observations upon it in his *Récherches sur les Egyptiens et les Chinois.* T. ii. p. 159.

and nearly all the excretions (except that of the semen, which is indeed rather unusual) suppressed. (A)

321. The remote causes of sleep are evident.* To say nothing of narcotics, it is induced by the expenditure of the animal powers from previous fatigue or watchfulness, also by habit, darkness, silence, rest, &c. which acquire their somniferous powers in some measure from habit, by mild, continued, and uniform impressions upon certain senses, v. c. the murmur of a rivulet or the view of a field of standing corn agitated by the wind, a previous meal, intense cold applied to the surface, and other modes of deriving blood from the head, as pediluvia, clysters, profuse hemorrhages.

322. These remote causes may induce the *proximate* cause, which, upon mature consideration, we think probably consists in a diminished or impeded flow of oxygenated (arterial) blood to the brain, for that fluid is of the highest importance, during the waking state, to the reaction of the sensorium upon the senses and voluntary motions.†

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* Although the lethargic winter torpor of the Alpine marmot, the cricetum, and many other mammalia brutes, differs importantly from the sleep now spoken of, modern observations respecting this torpor have shewn, that, in their phenomena and remote causes, both correspond and mutually elucidate each other. Consult, for instance, Sulzer, *Naturgeschichte des Hamsters.* p. 162.

Spallanzani, *Sur la Respiration.* Geneva. 1803. 8vo.

Mangili, and C. Ul. Von Salis in the latter's and Steinmüller's *Alpina.* T. iv. 1809.

Cuvier, *Analyse des Travaux de la Classe Physique de l'Institut.* 1807.

† Those who wish to know and compare other opinions upon the causes of sleep, may consult

M. de Grimaud, *Mémoire sur la Nutrition.* Petersb. 1789. 4to. p. 194.

Arn. Wienholt, *Heilkraft des thierischen Magnetismus.* T. ii. p. 439.

H. Nudow, *Versuch einer Theorie des Schlafs.* KŒNINGSBERG. 1791. 8vo.

Steph.

The influx of blood is diminished by its derivation from the brain and congestion in other parts; it is impeded by the pressure of foreign matter upon the brain, whether from serous or purulent collections, from depression of fractured bones, &c.

This diminution of, or impediment to, the flow of blood to the brain, causes a deficiency of water in the ventricles and a collapse of them, upon which that acute and deep physiologist, David Hartley, whom we have already praised, explains the various phenomena of dreams.* Besides other phenomena which accord with this explanation, is a very remarkable one which I witnessed in a living person whose case was formerly mentioned,—that of the brain sinking whenever he was asleep and swelling again with blood the moment he awoke.

This opinion is likewise strengthened by the production of continued watchfulness from congestion of blood in the head.

323. The quantity of sleep depends much upon age, constitution, temperament, &c.; generally speaking, much sleep is the attendant of weakness, as we find in infants born prematurely and in superannuated persons, and the very frequent source of fatuity and torpor.

Steph. Gallini at the end of his *Saggio d'Osservazioni su i nuovi progressi della Fisica del Corpo Umano.* Padua. 1792. 8vo.

Mauduit, in Fourcroy, in the *Médecine Eclairée*, &c. T. iv. p. 273.

T. Chr. Reil, *Functiones Organo Animæ Peculiares.* Hal. 1794. 8vo. p. 108.

L. H. Chr. Niemeyer, *Materialien zur Erregungstheorie.* Gotting. 1800. 8vo. p. 71.

Troxler, *Versuche in der Organischen Physik.* p. 435.

Brandis, *Pathologie*, p. 534.

* *Observ. on Man.* Vol. i. p. 48.

324. We awake refreshed with sleep; and this return to life is attended by the same phenomena as the approach of sleep,—by gaping, to which is generally associated stretching, by some degree of dulness of the senses, &c.

325. The causes of waking correspond with those of going to sleep.

The proximate is the more free return of blood to the head.

The remote are (besides the power of custom, which is in this respect very great) various stimuli applied to the external or internal senses, either immediately affecting the nervous system, as the distention of the bladder, or mediately, by the intervention of the imagination, as in dreaming.

326. *Dreams* are a sporting, as it were, of the imagination, in which it recalls the ideas of objects formerly perceived, especially of objects of sight, and appears to employ and interest itself with them.

It has been disputed whether dreams are natural during health. Some believe that they always occur during sleep, although they may escape our memory.* Others conceive them the consequence only of derangement in some of the abdominal viscera.† Very healthy adults have asserted that they never dreamt.‡

They are generally confused and irregular, but occasionally discover extraordinary marks of reason. §

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* Consult Kant, *Critik der Urtheilskraft.* p. 298. and *Anthropologie.* p. 80.

† v. F. Xav. Mezler, *von der Schwarzgallichten Constitution.* p. 80.

‡ v. Locke, *Essay concerning Human Understanding.* Vol. i. p. 74. Lond. 1726. 8vo.

§ See for instance what Hollmann has related of himself in this particular, *Pneumatolog. Psycholog. et Theol. Natural.* Gotting. 1780. 8vo. p. 196.

The power of corporeal stimulants is very great in producing dreams; v. c. of the semen in producing lascivious trains of ideas, of excessive repletion in causing frightful appearances. We have one instance of a man, in whom any kind of dreams could be induced, if his friends, by gently addressing him, afforded the subject-matter.* This, however, appears to be a preternatural state, between sleeping and waking; as does also the truly diseased case of sleep-walkers, and that affection which seizes them with what is termed magnetic ecstasy, which is, however, of a very different nature.†

Locke and others have regarded all dreams as a species of this mixed state. (C)

NOTES.

(A) Respiration also proceeds more slowly.

(B) It is certain that the supply of arterial blood to every part, and especially to the nervous system, is requisite to its functions and its life, and that in proportion to the activity of a part is the activity of its supply of arterial blood. Analogy, therefore, renders it more than probable, that, during the inactivity of sleep, the brain, having less occasion for arterial blood, has a less vigorous circulation than during the waking state; and we know that whatever diminishes the ordinary determination of blood to the brain (321), or impairs the movement of the blood

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* Beattie, *Dissertations Moral and Critical.* Lond. 1783. 4to. p. 217.

† G. Gottl. Richter, *De Statu Mixto somni et vigiliæ quo Dormientes multa Vigilantium munera obeunt.* Gotting. 1756. 4to.

Wienholt, l. c. Vol. iii. P. i. p. 10.

through it,* disposes to sleep.† But although this be granted, it must be viewed not as the ordinary cause, but as a circumstance, or in fact a consequence, of sleep. Increase the activity of an organ, you increase its circulation; diminish its activity, you diminish its circulation. The alteration of circulation is usually not the cause, but the consequence; necessary indeed to the continuance of the altered degree of activity in the organ, but not the cause. The degree of activity of any part, and the degree of its circulation, are exactly and unalterably correspondent. If the circulation through a part be mechanically increased or diminished, the sensibility and activity of the part will, doubtless, be proportionally increased or diminished. This example occurs in hemorrhage; frequently both are affected simultaneously,—when diarrhœa renders the surface pale and cold, both the blood is sent more sparingly to it, and the energy of its vessels is diminished by the increase of energy in those of the intestines (Sect. VI. Note.) But in ordinary sleep, the diminished circulation appears only the consequence, for activity is always followed by inactivity. Stimulate a muscle, separated from the body, it contracts, but it soon refuses to do so; after a little rest, it again contracts upon

* As arterial blood when at rest acquires the venous character, it is evident that in congestion of blood, by which is meant simply an unusual quantity of blood in a part, not flowing with its usual freedom, the part affected has not its proper supply of arterial blood. Hence congestion in the head must, from this cause alone, produce drowsiness.

† The phenomena of torpid animals are precisely analogous to those of common sleep. The sensibility and all the functions are lessened, the temperature is low, the circulation slow, respiration almost or quite imperceptible, and digestion suspended. This torpidity is produced by a deficiency of external excitants, usually by cold and want of food, and, in the language of Brown, is a state of direct debility, while our ordinary sleep is one of indirect debility. No structural peculiarity is discoverable, which enables certain animals to exist in the torpid state. See Dr. Reeve's *Essay on the torpidity of animals*, &c.

Some animals become torpid on being deprived of moisture. A common garden snail falls torpid if put in a dry place, and may be revived at any time by the application of a little water. Moisture has revived some animalcules after a torpidity of twenty-seven years. Spallanzani, *Opuscoli di Fisica animale e vegetabile.*

the renewal of the stimulus. The case of the brain is analogous; and when, after its daily activity, it falls asleep, the diminution of its circulation consequentiy ensues.

(C) In sleep the action of the mind is considerably suspended. But the degree of suspension is extremely various. In ordinary sleep the mind is sufficiently alert to feel unpleasant sensations and make an effort to remove their causes;—whether to remove the uneasiness of impeded circulation in the lungs by breathing, or to draw away the hand when tickled. Imagination is often active, and one idea associates with it another, constituting dreaming; but the activity of the mind is partial, and though we are able occasionally even to reason correctly in our dreams, we are not sufficiently ourselves to discover the incompatibility of many circumstances which we fancy. In a higher degree of activity, we answer questions put to us, although often ridiculously, as our deficiency of mental power prevents us from keeping our associations in a proper train; and we sometimes even perform a regular series of movements.

The great feature of sleep is the deficiency of our active powers. If we have any external sensation, or if the imagination riots on, presenting trains of images to our internal senses, we reflect upon them but weakly, make great mistakes, and however well we may reason, or whatever corporeal movement we execute, the inferiority of our active powers is conspicuous. But that active power is not suspended, as Mr. Dugald Stewart maintains in his theory of dreaming,* the simple fact of breathing during sleep, to say nothing of the other motions, and the acute, though circumscribed, reasoning which occasionally occurs, is a sufficient proof.

* *Elements of the Philosophy of the Human Mind.* Vol. 1.

SECT. XXI.

OF FOOD AND HUNGER.

327. As sleep repairs the loss of the animal powers, so food repairs that of the natural, and supplies fresh elementary particles in the room of those which are constantly wasting.

328. We are most effectually induced to procure and take food by various calls of nature, all tending to the same end: on one hand, by the intolerable torment of hunger and thirst; and on the other, by the equally powerful allurements of appetite.

329. Some ascribe *hunger* to an uneasiness arising in the stomach from its being empty and unoccupied; others to the mutual friction of its rugæ; others not only to the stimulus of its fluids, now secreted in abundance,—of the saliva and gastric juice, but to an acrimony which they acquire when food is not taken in proper time. (A)

330. *Thirst* appears referrible both to a very unpleasant dryness of the fauces, and to the particular stimulus of acrid matters, especially of salts, taken by the mouth. It may be, therefore, the consequence of excessive absorption in the cavity of the mouth, such as occurs when the mother applies her infant to the breast, or, what is not uncommon, when venesection or purging have been ordered. Violent passions frequently induce thirst. (B)

331. The necessity of obeying these stimuli is greater or less according to age, constitution, and especially according to habit, and nothing can therefore be positively affirmed respecting its urgency; but thus much is certain, that an healthy adult, in whom all the calls of nature are felt in their usual force,* cannot abstain from food a whole day without great prostration of strength, nor scarcely beyond eight days without danger to life. (C).

332. Although thirst is a violent desire, drink appears not very necessary to life and health; for many warm blooded animals,—mice, quails, parrots, &c. do not drink at all; and some individuals of the human species have lived in perfect health and strength without tasting liquids.†

333. It has been disputed whether our *food*, by which we satisfy these stimuli, is derived more advantageously and the more consistently with nature from the animal or from the vegetable kingdom.‡

334. Some contend that man is herbivorous, from the shape of his teeth,§ the length of his intestines,|| the difference between the structure of the small and large intestines, and from the cells of the colon. Rousseau ingeniously urges the circumstance that woman is na-

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* Consult, among innumerable writers on long fasting, James Barthol. Beccarius, *Commentar. instituti Bononiens,* T. ii. p. 1. and Flor. J. Voltelen, *Memorab. apositiæ septennis hist.* LB. 1777. 8vo.

† G. Baker, *Med. Transact. published by the Coll. of Physicians in London.* vol. ii. p. 265 sq.

‡ J. W. Neergaard, *Vergleichende Anatomie und Physiologie der Verdauungswerkzeuge der Saügethiere und Vögel.* Berlin. 1806. p. 244.

§ Gassendi, *Letter* to J. Bapt. v. Helmont. Opera. Florence. 1727. fol. T. vi. p. 17. Al. Monro, Senr. *Essay on Comparative Anatomy.* p. 17.

|| J. Wallis, *Philos. Trans.* No. 269.

turally uniparous and provided with two breasts.* To these arguments it may be added, that some men have ruminated,—a power peculiar to herbivorous animals, and that tame vegetable feeders are easily accustomed to animal food, whereas carnivorous animals, excepting the dog, can very seldom be brought to feed on vegetables.

The arguments of those who, with Helvetius,† regard man as carnivorous, are derived from the conformation of his stomach, the shortnes of his cœcum, &c.

335. More careful observation, however, proves that man is not destined for either kind of food alone, but for both. His teeth, particularly the molares,‡ (D) and the peculiar structure of the intestines just alluded to, (E) hold a middle rank between the same parts in the feræ and in herbivorous animals. The mode in which the condyles of the lower jaw are articulated with the temporal bones, demonstrates it in the most striking manner (F).

336. As the human race exists in more parts of the globe than any other kind of animal, we should have been but ill provided for, if we had been destined to subsist on either description of food alone; whereas man now inhabits some countries which afford either vegetable or animal food only.

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* *Sur l'origine de l'inégalité parmi les hommes.* p. 196 sq.

† *De l'homme.* T. ii. p. 17.

‡ The opinion of Broussonet is singular. He thinks the human molares closely resemble the teeth of herbivorous animals, and at the same time regards the incisores and canini as allied to those of the carnivorous tribes: and, after comparing the *number* of the molares with that of the other teeth, concludes that the quantity of vegetable food intended for man is to the quantity of animal food as 20 to 12.

But on this calculation it follows, that infants, who have four molares only in each jaw, are destined to consume a larger portion of animal food than adults, since the proportion of the molares to the other teeth is in them as 8 to 12.

337. Man is by far the most omnivorous of all animals, capable not only of feasting on luxurious combinations derived from each kingdom, but of subsisting with health and vigour on nearly one kind of the most simple food.

Thus, to mention a very few instances, many at present live on vegetables only, as the tubera of solanum (potatoes), chesnuts, dates, &c. The first families of mankind most probably subsisted for a long period merely on fruits, roots, corn, and pulses.*

The nomadic Moors have scarcely any other food than gum senega.† (G)

The inhabitants of Kamtschatka and many other shores scarcely any other than fish.

The shepherds in the province of Caracas in South America on the banks of the Oronoko,‡ and even the Morlachi § in Europe, live almost entirely on flesh.

Some barbarous nations devour raw animals. This cannot be denied to have been formerly the case with the Samojedes,|| the Esquimaux,** and some tribes of South America.††

Other nations are no less remarkable in their drink.

The inhabitants of many intertropical islands, especially in the Pacific Ocean, can procure no sweet water, and instead of it drink the juice of cocoa-nuts.

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* Consult my very dear friend Heyne, *Opuscula Academ.* vol. i. p. 366 sq.

† Adanson, *Mém. de l'Acad. des Sc.* de Paris. 1778. p. 26.

‡ Fil. Salv. Gily, *Saggio di storia Americana.* vol. iv. p. 120.

§ Gius. Ant. Pujati, *Reflessioni sul vitto Pitagorico.* Feltri. 1751.

|| (De Klingstaedt) *Mém. sur les Samojedes et les Lappons.* 1762. 8vo.

** Curtis, *Philos. Transact.* Vol. lxiv. P. ii. p. 381, 383.

†† T. Winter in Hakluyt's *Principal Navigations of the English Nation.* Vol. iii. p. 751.

Others take only sea-water.

Innumerable similar facts clearly prove man to be omnivorous.

NOTES.

(A) If hunger arise from merely a sense of vacuity in the stomach, why should it be increased by the application of cold to the surface, the deglutition of cold liquids, &c.?

The explanation by friction of the rugæ is equally unsatisfactory; because the friction of these, if it does really occur, cannot be greater than the friction of the stomach against its contents immediately after a meal, at which time hunger does not exist.

Nor can the presence of the gastric juice explain the matter; because, as every one knows, no mental sensation arises in any other organ that is not excrementory, from the peculiar stimulus of its natural fluid; and I presume that this is the stimulus alluded to, because the mechanical stimulus from the bulk of the gastric juice, occurs equally from the presence of food, which does not excite hunger.

The supposition of an acrimony generated in the gastric juice, &c. being a cause of hunger, is absurd; the fluid would be unfit for its purposes, and would be more likely to destroy than produce appetite.

Hunger has been attributed by some to a sympathy of the stomach with a general feeling of want in the system. But hunger is removed immediately that a due quantity of food is swallowed, long before the general system can have derived benefit from the meal; fowls are satisfied when their crops are filled, although their food is not even ground, *preparatorily* to digestion, till it has passed from the crop into the gizzard, and ruminating animals leave off eating before they begin to chew what they have distended their stomachs with. The circumstance giving rise to this opinion is the continuance of hunger, although food be taken in abundance, in cases of scirrhus pylorus and enlarged mesenteric glands. Here, it is urged, the hunger continues, because the body receives no nourishment. But, in scirrhus of the pylorus, vomiting soon follows the reception of food into the stomach, and therefore this organ is reduced to the condition in which it was previously, and the return of hunger is easily explicable. In diseases of the mesenteric glands, there is in fact no obstruction to the course of the chyle. They are found permeable (427), and the continued hunger appears rather a part of the diseased state of the chylopoietic viscera. Besides, many cases of imperfect nutrition, from various causes, occur without any increase of appetite. In continued abstinence, although the system is daily more in want, hunger usually ceases in a few days, whether from the stomach falling into a state of relaxation, becoming distended with wind, or other circumstances.

If hunger arose from fatigue of the stomach, it should be greatest immediately after the laborious action of digestion, and gradually decrease; but it on the contrary increases.

Were irritation the cause, hunger should be greatest when the stomach is filled with food.

On the whole, hunger may perhaps be regarded as a sensation connected with the contracted state of the stomach and the corrugation of its inner coat.

It occurs when the stomach, being empty, must be contracted, and the inner coat corrugated; and is increased by cold drink, by cold air applied to the surface, by acids, bitters, and astringents, —all which may be presumed to corrugate the inner coat of the organ. It is diminished by heat and every thing which relaxes. Again, it ceases immediately that the stomach is filled and thus all corrugation removed, and the more the contents of the stomuch are of a nature to be absorbed or passed into the duodenum, the sooner it recurs.

Being, in this view, a sensation connected with a local state of the stomach, it will be affected not only by whatever affects this state, but by whatever affects also the sensibility to this state, and therefore be subject to the common laws of sensation. Hence uncivilized tribes enable themselves to traverse large tracts without food by swallowing pills containing tobacco or opium. Thus, the state of the stomach remaining the same, hunger may diminish from the occurrence of other sensations which attract our attention more forcibly, by passions of the mind, &c.; as is exactly the case with all other sensations, even with those that are morbid.—Under strong attention of the mind either to pursuits of intellect or passion, to delightful or painful sensation, all other sensations cease to be felt, although really violent; and frequently, from being unattended to, do not recur. Passions, however, may affect hunger, not only by increasing or diminishing the sensibility to the state of the stomach, but by increasing or decreasing this state—the cause of the sensation.

(B) As hunger appears to depend upon the local condition of the stomach, &c. so does thirst more evidently upon that of the mouth and fauces. Every consideration renders it probable that thirst is the sensation of the absence of moisture in the parts in which it is seated. Whatever produces this, either by causing the fluids of the mouth and fauces to be secreted in small quantities or of great viscidity, or by carrying off the fluid when secreted, produces thirst; and vice versa. To be dry means to be thirsty, because the state is removed by directly wetting the parts, or by supplying the system with fluid that they may be moistened by their own secretions. Being a sensation, the same may be repeated in regard to it as was observed respecting hunger.

(C) "Most of those," says the Father of Physic, "who neither eat nor drink for seven days, die within that period; and if they survive and take nourishment, still the previous fasting proves fatal." * A girl, however, able to eat and drink and

* Hippocrates, *De carnibus.* S. iii.

apparently not in bad health, was extricated from the ruins of a house at Oppido, in which she had remained eleven days without food: an infant in her arms, but a few months old, died on the fourth day, as the young are never so able to endure abstinence.* A moderate supply of water lengthens life astonishingly. Dr. Willan was called to a young gentleman who had voluntarily abstained from every thing but a little water, just flavoured with orange *juice*, for sixty days: death ensued a fortnight afterwards.† Pouteau mentions a young lady thirteen years of age, that lived eighteen months and grew two inches and a half, on syrup of capillaire and water.‡ Redi cruelly found that of a number of starved fowls deprived of water, none lived beyond the ninth day, whereas one indulged with water lived upwards of twenty.

A hog, weighing about 160 lbs. was buried in its stye under thirty feet of the chalk of Dover Cliff for 160 days. When dug out, it weighed but 40 lbs., and was extremely emaciated, clean, and white. There was neither food nor water in the stye when the chalk fell. It had nibbled the wood of the stye and eaten some loose chalk, which from the appearance of the excrement had passed more than once through the body. §

In abstinence equally great imbecility of mind takes place as of body; urine may still be secreted, but the alvine discharge is greatly diminished or suppressed altogether; the pain of hunger ceases in a few days.

The torment of thirst increases until drink is procured or moisture applied to the surface or inhaled: inflammation of the mouth and throat and intense fever at length ensue.

If abstinence is not forced upon the system, but is absolutely a part of disease, it may, like immense doses of powerful medicines in various diseased states, be borne with wonderful

* *Phil. Trans.* Vol. lxxiii. p. 169.

† Medical Communications. Vol. ii.

‡ *Œuvres Posthumes.*

§ *Linnæan Transac.* Vol. xii.

indifference, and this occurs chiefly among females. The most extraordinary case that I recollect, stated too upon unquestionable authority,* is that of a young Scotch woman, who laboured under an anomalous nervous affection, and, excepting that on two occasions she swallowed some water, received no nourishment whatever for eight years. She passed urine enough twice a week to wet a shilling, and for three years had no motion.†

In an extraordinary instance of imperfect abstinence during fifty years, the woman voided a little feculent matter like a piece of roll-tobacco or a globule of sheeps' dung, but once a year, and that always in March, for sixteen years.‡

For every example of extraordinary abstinence among females, we have a counterpart in voraciousness among males. When the appetite is so great it is seldom nice, and not only all animals in all states are devoured, but glass, flints, metals, sand, wood, &c. A Frenchman named Tarare, and described by MM. Percy and Laurent in some measure from their own observation, § will form a good contrast to the Scotch girl. When a lad he once swallowed a large basket of apples after some person had agreed to pay for them, and at another time a quantity of flints, corks, and similar substances. The colic frequently compelled him to apply at the Hotel Dieu; but he was no sooner relieved than he began his tricks again, and once was but just prevented from swallowing the surgeon's watch, with its chain and seals. In 1789 he joined the mob and obtained sufficient food without devouring for money. He was then about seventeen, weighing a hundred pounds, and would eat five-and-twenty pounds of beef a day. When the war broke out he entered into the army, and devoured his comrades' rations, as long as better supplies from

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* *Philos. Trans.* Vol. lxvii.

† *Edinb. Med. and Phys. Essays.* Vol. vi.

‡ It would be interesting to examine the changes induced in the air by the lungs and skin of such patients.

§ *Dictionnaire des Sciences Médicales*, art. Homophage. See also the former's Mémoire sur le Polyphage in the *Journal de Médecine*. Brumaire. An xiii.

other sources rendered them of little value. But when at length his comrades stood in need of them themselves, he was nearly famished, fell ill, and was admitted into the *hôpital ambulant* at Sultzer. He there ate not only a quadruple allowance, the broken food of the other patients, and the waste of the kitchen, but would swallow the poultices and any thing else that came in his way. He devoured so many dogs and cats alive that they fled at the sight of him. Large snakes he despatched with the greatest facility, and once gobbled up in a few moments all the dinner that was provided for fifteen German labourers, viz. four bowls of curd and two enormous dishes of dough boiled in water with salt and fat. At another time he disposed of thirty pounds of raw liver and lights in the presence of some general officers, who, finding that he could swallow a large wooden lancet case, took the partitions out, enclosed a letter in it, and made him swallow it and proceed to the enemy's quarters for the purpose of discharging it by stool and delivering the letter to a French colonel who had fallen into the hands of the Prussians. This he contrived to do, enclosed the answer in it, swallowed it again, made his escape, discharged the case again from his bowels, washed it, and presented it to Beauharnois and the other officers. Having, however, been well drubbed by the enemy, he refused any further secret service and was readmitted into the hospital to be cured of his hunger. Being no longer a novelty, less interest was taken in him, and he felt it necessary to have recourse to sheep-folds, poultry-yards, private kitchens, slaughter-houses, and bye places where he had to contend with dogs and wolves for their filthy food. He was detected drinking blood that had been taken from his fellow-patients, and eating bodies in the dead house. The disappearance of a young child excited strong suspicions against him, and he was at length chased away and unheard of for four years, at the end of which time he applied at the hospice de Versailles, wasted, no longer voracious, and labouring under a purulent diarrhœa, and he soon died, aged twenty-six. The body immediately became a mass of putridity.

During his life he always was offensive, hot, and in a sweat, especially at intervals. His breath rolled off like steam, and dejections were constantly most copious and intolerably fœtid. He was of the middle height, thin, and weak.

All the abdominal viscera were found full of suppurations.

His stomach was of immense size, and this has usually been the case in persons habitually gluttonous. A polyphagous idiot opened by the same writers displayed an enormous stomach, more resembling that of a horse than of a human being: the intestines also formed several large pouches in succession, which appeared like additional stomachs. Cabrol dissected a glutton of Toulouse, and found the œsophagus terminating in an excessively large cavity and the intestines running, without a single convolution, but with merely a gentle sygmoid flexure, to the anus. We thus learn the common cause of constitutional voraciousness and obtain an additional reason for referring hunger to the want of distention of the stomach:—a great bulk of food was required to *fill* these stomachs. If hunger were independent of the distention of this organ, and connected solely with the want of the system, an ordinary meal would have always sufficed, as the extraordinary quantity of food could not be demanded for nourishment, — when food enough for support had been taken, hunger should have ceased. But hunger continued till the stomach was filled, and the prodigious collection was disposed of by abundant stools, sweating, and copious pulmonary exhalation.

The large capacity of the stomach is generally ascribable to original conformation, but some account for it occasionally by repeated over-distention and the deglutition of indigestible substances,—an opinion rather improbable when we reflect that city gluttons, who give a very fair trial to the distensibility of their idol, never acquire such appetites and capaciousness of stomach as qualify them for a show. The power of deglutition may be very much increased by practice. We have all seen the Indian jugglers, and I frequently conversed with a poor man who had swallowed nineteen large clasped knives at different times, having found in a drunken fit that he could get one down his throat for a wager: * yet in him the appetite and capacity of stomach were not augmented.

Some great eaters are prodigies of strength; as Milo, who killed an ox with a blow of his fist and then devoured it, and the fellow mentioned in a thesis published at Wittemberg in 1757, who once, in the presence of the Senate, ate up a sheep, a sucking-pig, and sixty pounds of plums, stones and all, and could carry four men a whole league upon his shoulders.

Voraciousness is of course sometimes, like depraved appetite, but temporary and referrible to merely disordered function. Dr. Satterly details the case of a lad in whom, while labouring under typhus with marked inflammation in the head, the exacerbations of fever were accompanied by such hunger, that he ate every day four regular meals, each sufficient for the stoutest labourer's dinner, and many pounds of dry bread, biscuit, and fruit between them. He had no sooner finished a meal than he denied having tasted any thing, and would suck and bite the bed-clothes or his fingers if refused more, cared nothing about the quality of what he ate, would pass six or seven large solid motions a day by means of physic, and ultimately recovered.† The stomach here executed its office with excessive rapidity.

(D) In carnivorous animals, the incisors are very large; and the molares generally of an irregular wedge form, those of the lower jaw closing in those of the upper like scissars, and being adapted for lacerating. In the herbivorous, the surface of the molares is horizontal or oblique, adapted for grinding.

(E) As the food of herbivorous animals requires more preparation before it becomes the substance of the animal, their stomach is adapted to retain it for a length of time. The œsophagus opens nearer the right extremity of the stomach, and the

* The stomach with several knives in it is preserved in the Museum of Guy's Hospital.

† *Transactions of the Royal College of Physicians, London.* vol. v.

pylorus nearer the left, so that a blind pouch is left on either side. In the carnivorous, the reverse is the case, and the stomach cylindrical, to favour the quick passage of the food. For the same reason, the intestines in the latter, even in insects, are generally shorter, and have fewer valvulæ conniventes, and, in some instances, no cœcum.

(F) In animals which subsist on animal food, the condyles of the lower jaw are locked in an elongated glenoid cavity, and all rotatory motion thus prevented, as motion upwards and downwards is sufficient for the laceration of the food. In vegetable feeders the joint is shallow, so that a horizontal motion is allowed for grinding the food. For its nature in man, see paragraph 339.

(G) In 1750, a caravan of Abyssinians had consumed all their provisions, and would have starved but that they discovered among their merchandise a stock of gum arabic, on which alone a thousand persons subsisted for two months.* Yet M. Majendie found that dogs perished if fed only with gum or sugar, olive oil, butter, and similar articles, regarded as nutritious, that contain no azote.† But although such substances be alone unable to nourish, yet when united with others they may afford some support, for persons accustomed to a mixed diet generally grow thinner, if they confine themselves to vegetable food, which is indubitably good nourishment, and even if we grant that such substances are not nutritious to dogs, they may be proper food for other species; and to prove even that these are not nutritious to dogs, the animals should have been gradually brought to feed on them only. For animals may be brought to live on food the most opposite to what their nature inclines them, if the change is made insensibly:—Spallanzani made a pigeon live on flesh and an eagle on bread; if fresh water molusca are put into sea water, or sea water molusca into fresh water, they perish; but

* Hasselquist, *Voyages in the Levant.* p. 298.

† *Annales de Chimie et de Phisique.* iii. 126. 1815.

if the change is gradually made, they live very well;* a spider has lived upon sulphate of zinc;† the Ottomans eat little else than large quantities of baked earth some months of the year;‡ and indeed the negroes of Guinea, the Javanese, and wolves, occasionally devour it.

It appears that matter which has never belonged to an animated system is calculated to afford nourishment to animals in some degree, but subordinately to matter which has belonged to vegetables or animals, and that it alone will in some instances support life for a time. Vegetables will indisputably live with facility on such alone; and it has been contended that some animals, as fish, and vegetables, readily subsist and grow on simple water, but the experiments in support of this assertion are not quite decisive.

* l. c. ij. 32. 1815.

† Thomson's *Annals of Philosophy*. xij. 454.

‡ Humboldt, *Tableaux de la Nature*. Vol. i.

SECT. XXII.

OF MASTICATION AND DEGLUTITION.

338. THE lower jaw is the chief organ of mastication, and is supplied, as well as the upper, with three orders of teeth.

With incisores, generally * scalpriform for the purpose of biting off small pieces, and not placed in the lower jaw, as in other mammalia, more or less horizontally, but erect,—one of the distinctive characters of the human race.

With strong conical canine teeth, by which we divide hard substances, and which in man neither project beyond the rest, nor are placed alone, but lie closely and in regular order with the others.

With molares of various sizes, adapted for grinding, and differing conspicuously from those of other mammalia, by possessing gibbous apices excessively obtuse.

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* I say generally: for, omitting particular examples of their obtuseness, I may remark that, in the skulls of most mummies, I have found the crown of the incisores thick and obtuse. And since the more remarkable for this variety have resembled, in their general figure and appearance, the singular and never-to-be-mistaken physiognomy of the ancient Egyptians, observable in the idols, sarcophagi, and statues of ancient Egypt, it is probable that this peculiar form of the teeth, whether owing to diet or whatever else, was peculiar to the ancient Egyptians, so that it may be regarded as a natural mark or even characteristic by which true ancient mummies may be distinguished from those of late formation.

I have written at large on this subject in the *Philos. Trans.* 1794. P. II. p. 184.

339. The lower jaw is connected with the skull by a remarkable articulation, which holds a middle rank between arthrodia and ginglymus, and, being supplied with two cartilaginous menisci of considerable strength, affords an easy motion in every direction.

The digaster, assisted by the geniohyoidei and mylohyodei muscles, draws the lower jaw down, when we open the mouth.

The masseters and temporal chiefly raise it again when we bite off any thing, and are most powerfully contracted when we break hard substances.

Its lateral motions are accomplished by the internal and external pterygoid.

The latter can also draw it forwards.

340. Substances are retained in the mouth and moved and brought under the action of the teeth by the buccinator, and by the tongue which is very flexible and changeable in form. (235)

341. During manducation, there occurs a flow of *saliva*,* which is a frothy fluid, consisting of a large portion of water united with some albumen, and holding in solution a small quantity of phosphate of lime—the source of the tartar of the teeth and of salivary calculi. From being constantly applied to the tongue, it is insipid, although it contains some microcosmic salt (phosphate of ammonia), as well as muriatic and, invariably, a small portion of oxalic, acid. It is antiseptic† and very resolvent. (A)

* J. Barth. Siebold, *Historia Systematis Salivalis*. Jen. 1797. 4to. with copper-plates.

† Pringle, *On the Diseases of the Army*. Append. p. XLVIII. L. LXI. sq. Lond. 1765. 4to.

342. The saliva flows from three orders of conglomerate glands, placed laterally and interiorally with respect to the lower jaw.

The principal are the *parotids*,* which pour forth the saliva behind the middle molares of the upper jaw, through the Stenonian ducts.†

The *submaxillary*,‡ through the Whartonian.§

The *sublingual*, ‖—the smallest, through the numerous Rivinian.**

343. The excretion of saliva, amounting, according to the arbitrary statement of Nuck,†† to a pound in twelve hours, is augmented by stimuli and by mechanical pressure, or, if the expression may be allowed, emulsion.

The latter cause, greatly favoured by the situation of the parotids, at the articulation of the jaws, occurs when we chew hard substances, which thus become softened.

The former occurs when acrid substances are taken into the mouth, which are thus properly diluted; or arises from imagination, (288) as when the mouth waters during the desire for food.

344. The mucus of the labial and buccal glands‡‡ and of the tongue, as well as the moisture which trans-

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* De Courcelle, *Icones Musculorum Capitis.* Tab. I. *g. h.*

† Stenonis, *Observationes Anatomicæ.* p. 20.

‡ De Courcelles, l. c. Tab. II. *t. t.*

§ Wharton, *Adenographia.* p. 120.

‖ De Courcelle, tab. V. *g. g. g.*

** Rivinus, *De Dyspepsia.* Lips. 1678. 4to.

Aug. Fr. Walther, *De Lingua Humana.* ib. 1724. 4to.

†† Nuck, *Sialographia.* p. 29 sq.

‡‡ De Courcelles, l. c. Tab. IV. *e. e. e.*

udes from the soft parts of the mouth, is mixed with the saliva.

345. The mixture of these fluids with a substance which we are chewing, renders it not only a pultaceous and easily swallowed bolus, but likewise prepares it for further digestion and for assimilation.

346. The mechanism * of deglutition, although very complicated and performed by the united powers of many very different parts, amounts to this. The tongue being drawn towards its root, swelling and growing rigid, receives the bolus of food upon its dorsum, which is drawn into a hollow form. The bolus is then rolled into the isthmus of the fauces, and caught with a curious and rather violent effort by the infundibulum of the pharynx, which is enlarged and in some measure drawn forward to receive it. The three constrictores † muscles of the pharynx drive it into the œsophagus. These motions are all performed in very rapid succession and require but a short space of time.

347. Nature has provided various contrivances for opening and securing this passage.‡

The important motion of the tongue is regulated by the os hyoides.

The smallest particle of food is prevented from entering the nostrils or eustachian tubes, by means of the soft palate,§ which, as well as the uvula suspended from

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* Fr. Bern. Albinus, *De Deglutitione.* LB. 1740. 4to.

P. J. Sandifort, *Deglutitionis Mechanismus.* LB. 1805. 4to.

† Eustachius, Tab. XLII. fig. 4, 6.

Santorini, *Tab. Posthum.* VI. fig. 1.

B. S. Albinus, *Tab. Musculor.* XII. fig. 23, 24.

‡ J. C. Rosenmüller, *Icones Chirurgico-Anatomicæ.* Fasc. 1. Vinar. 1805. fol.

§ Littre, *Mém. de l'Acad. des Sc. de Paris,* 1718. tab. XV.

its arch, and whose use is not clearly understood, is extended by muscles of its own, and closes those openings.*

The tongue protects the glottis, for the larynx at the moment of deglutition is drawn upwards and forwards, and in a manner concealed under the retracted root of the tongue and applied to the latter in such a way, that the glottis, being also constricted and protected by the epiglottis, is most securely defended from the entrance of foreign substances. (B)

348. Deglutition is facilitated by the abundance of mucus which lubricates these parts, and which is afforded not only by the tongue (237), but by the numerous sinuses † of the tonsils and cryptæ of the pharynx.

349. The *œsophagus,* through which the food must pass previously to entering the stomach, is a fleshy canal, narrow and strong, mobile, dilatable, very sensible, and consisting of coats resembling, except in thickness, the coats of the other parts of the alimentary canal.‡

The external coat is muscular, and possesses longitudinal and transverse fibres.

The middle is tendinous, lax, more and more cellular towards each of its surfaces, by which means it is connected with the two other coats.

The interior is lined, like all the alimentary tube,

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* Santorini, *Tab. Posthum.* IV.—VI. fig. 2.—and VII.

B. S. Albinus, *Tab. Musculor.* XII. fig. 11, 27, 28.

† B. S. Albinus, *Annotat. Acad.* L. III. tab. III. fig. 1, *n.*

‡ Matth. Van. Geuns, *Verhandelingen van de Maatschappye te Haarlem.* T. XI. p. 9 sq.

Jan. Bleuland, *Observ. de structura œsophagi.* LB. 1785. 4to.

with an epithelium analogous to cuticle, (176) and is lubricated by a very smooth mucus.

350. This canal receives the approaching draught or bolus of food, contracts upon it, propels it downwards, and, in the case of the bolus, stuffs it down, as it were, till it passes the diaphragm and enters the stomach.

NOTES.

(A) Saliva is composed of

Water - - - - - -	992 . 9
A peculiar animal matter - -	2 . 9
Mucus - - - - - -	1 . 4
Alkaline muriates - - - -	1 . 7
Lactate of soda and animal matter -	0 . 9
Pure soda - - - - -	0 . 2
	1000 . 0*

What Berzelius calls mucus, Professor Thomson and Dr. Bostock regard as albumen. It is insoluble in water, and when incinerated, but not before, yields a large portion of phosphate of lime. The tartar of the teeth arises from its gradual decomposition upon them, and consists of

Earthy phosphates - - - -	79 . 0
Undecomposed mucus - - -	12 . 5
Peculiar salivary matter - - -	1 . 0
Animal matter soluble in muriatic acid	7 . 5
	600 . 0†

(B) The glottis, when sound, may be sufficiently closed independently of the epiglottis. M. Majendie saw two persons perfectly destitute of epiglottis who always swallowed without difficulty.—*Précis Elémentaire,* T. ii. p. 63.

* J. Berzelius, *Medico-Chirurgical Transactions.* Vol. iii. p 242.

† Berzelius.

SECT. XXIII.

OF DIGESTION.

351. The *stomach* is the organ of digestion. It exists, what cannot be affirmed of any other viscus, in perhaps all animals without exception; and, if the importance of parts may be estimated in this way, evidently holds the first rank among our organs.

352. The human stomach * resembles a very large leathern bottle, is capable in the adult of containing three pints and upwards of water, and has two openings.

The superior, called *cardia,* at which the œsophagus, folded and opening obliquely, expands into the stomach, is placed towards the left side of its fundus.

The inferior, at which the right and narrower part of the stomach terminates, is called *pylorus,* and descends somewhat into the cavity of the duodenum.

353. The situation of the stomach varies accordingly as it is in a state of repletion or depletion. When empty, it is flaccid and hangs into the cavity of the abdomen, its greature curvature inclining downwards, while the pylorus, being directed upwards, forms by doubling, an angle with the duodenum.†

When full, the larger curvature is rolled forwards,‡

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* Eustachius, tab. x. fig. 1, 2, 3. Ruysch, *Thes. Anat.* ii. Tab. v. fig. 1. Santorini, *Tab. Posth.* xi.

† Vesalius, *De c. h. Fabrica.* L. v. fig. 14, 15.

‡ Id. l. c. fig. 2.

so that the pylorus lies more in a line with the duodenum, while the cardia, on the contrary, is folded, as it were, into an angle and closed.

354. The stomach is composed of four principal coats, separated by the intervention of three others which are merely cellular.

The *external* is common to nearly all the alimentary canal, and continuous with the omentum, as we shall presently mention.

Within this, and united to it by cellular membrane, lies the *muscular* coat, which is particularly worthy of notice from being the seat of the extraordinary irritability (300) of the stomach. It consists of strata of muscular fibres,* commonly divided into three orders, one longitudinal and two circular (straight and oblique), but running in so many directions that no exact account can be given of their course.

The third is the chief membrane. It is usually termed *nervous*, but improperly, as it consists of condensed mucous tela, more lax on its surfaces, which are united on the one hand with the muscular and on the other with the internal villous coat. It is firm and strong, and may be regarded as the basis of the stomach.

The *interior*, (besides the epithelium investing the whole alimentary canal) improperly called villous, is extremely soft and in a manner spongy, porous, and folded into innumerable rugæ,† so that its surface is more extensive than that of the other coats; it exhibits very small cells,‡ somewhat similar to those larger

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* Besides Haller, consult Bertin, *Mém. de l'Acad. des Sc. de Paris.* 1761.

† Ruysch, *Thes. Anat.* ii. Tab. v. fig. 2, 3, 4*.

‡ See G. Fordyce, *on the Digestion of Food.* p. 12, 59, 191.

cells which are so beautiful in the reticulum of ruminants.

Its internal surface is covered with mucus, probably secreted in the muciparous crypts which are very distinct about the pylorus.

355. The stomach is amply furnished with nerves* from each nervous system (214), whence its great sensibility, owing to which it is so readily affected by all kinds of stimuli, whether external, as cold, or internal, as food and its own fluids, or mental; whence also the great and surprising sympathy between it and most functions of the system; to which sympathy are referrible the influence of all passions upon the stomach, and of the healthy condition of the stomach upon the tranquillity of the mind.†

356. The abundance and utility of the blood-vessels of the stomach are no less striking. Its arteries, ramifying infinitely upon the cellular membrane and glands, secrete the *gastric juice*, which would appear to stream continually from the inner surface of the stomach.

357. In its general composition this fluid is analogous to the saliva, equally antiseptic, very resolvent,‡ and capable of again dissolving the milk which it has coagulated.§ (A)

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* Walter, *Tab. Nervor. Thorac. et Abdom.* tab. iv.

† J. H. Rahn, *Mirum inter Caput et Viscera Abdominis Commercium.* Gotting. 1771. 4to.

Did. Veegens, *De Sympathia inter Ventriculum et Caput.* LB. 1784. 4to.

Wrisberg, *Commentat. Societ. Scientar. Gotting.* T. xvi.

‡ Ed. Stevens, *De Alimentorum Concoctione.* Edinb. 1777. 8vo.

Laz. Spallanzani, *Dissertazioni di Fisica Animale e Vegetabile.* Modena. 1780. 8vo. Vol. i.

§ See Veratti, *Comment. Instituti Bononiens.* Tom. vi.

358. Digestion is performed principally by it. The food, when properly chewed and subacted by the saliva, is dissolved* by the gastric fluid, and converted into the pultaceous chyme, so that most kinds of ingesta lose their specific qualities, are defended from the usual chemical changes to which they are liable, such as putridity, rancidity, &c. and acquire fresh properties preparatory to chylification.† (B)

359. This important function is probably assisted by various accessory circumstances. Among them, some particularly mention the *peristaltic motion*, which, being constant and undulatory, agitates and subdues the pultaceous mass of food.‡

The existence of a true peristaltic motion in the stomach during health, is, however, not quite certain; the undulatory agitation of the stomach which occurs, appears intended for the purpose of driving the thoroughly dissolved portions downwards, while those portions which are not completely subacted are repelled from the pylorus by an antiperistaltic motion.

360. The other aids commonly enumerated, are the pressure on the stomach from the alternate motion of the abdomen, and the high temperature maintained in the stomach by the quantity of blood in the neighbouring viscera and blood-vessels, which temperature was at one time supposed to be of such importance, that the word coction was synonymous with digestion.

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* Even the stomach itself, when deprived of vitality, has been found acted upon, and, as it were, digested, by it. See John Hunter, *On the digestion of the stomach after death. Philos. Trans.* Vol. lxii.

† Ign.Doellinger, *Grundiss derNaturlehre des menschlichen Organismus.* p.88.

‡ Wepfer, *Cicutæ Aquaticæ Historia et Noxæ;* in innumerable places.

361. To determine the time requisite for digestion is evidently impossible, if we consider how it must vary according to the quality and quantity of the ingesta, the strength of the digestive powers, and the more or less complete previous mastication.

During health, the stomach does not transmit the digestible parts of the food before they are converted into a pulp. The difference of food must therefore evidently cause a difference in the period necessary for digestion.* It may, however, be stated generally, that the chyme gradually passes the pylorus between three and six hours after our meals. (C)

362. The *pylorus* † is an annular fold, consisting not, like the other rugæ of the stomach, of merely the villous, but also of fibres derived from the nervous and muscular, coats. All these, united, form a conoidal opening at the termination of the stomach, projecting into the duodenum, as the uterus does into the vagina, and, in a manner, embraced by it.

NOTES.

(A) Seven grains of the inner coat of a calf's stomach were found by Dr. Young to enable water poured upon it to coagulate 6857 times its weight of milk.

* See J. Walaeus, *De Motu Chyli.* p. 534. LB. 1651. 8vo.

† H. Palm. Levelling, *Dissert. sistens Pylorum, &c.* Argent. 1764. 4to. Reprinted in Sandifort's *Thes.* Vol. iii.

(B) It was once imagined that fermentation, and once that trituration, was the cause of digestion, but as neither can produce the same effects on food out of the body that occur in the stomach, these opinions fell to the ground. Besides, no signs of fermentation appear when digestion is perfect, and food defended from trituration by being swallowed in metallic balls perforated to admit the gastric juice, is readily digested.

(C) The digestive process does not go on equally through the whole mass of food, but takes place chiefly where it is in contact with the stomach, and proceeds gradually from the superficies to the centre of the mass, so that the food at the centre is entirely different in appearance from that at the surface, and as soon as a portion is reduced to a homogeneous consistence, it passes into the duodenum without waiting till the same change has pervaded the whole.*

The cardiac portion of the stomach is the chief seat of the process, and when a part of the food is tolerably digested it passes along the large curvature to the pyloric portion, where the process is completed. As the cardiac half is the great digesting portion, it is this half that is found dissolved by the gastric juice; its contents are much more fluid than those of the pyloric half; and Dr. Philip, who by the dissection of about a hundred and thirty rabbits has been enabled to furnish the completest account of what goes on the stomach, relates the case of a woman who had eaten and properly digested to the last, but whose stomach was ulcerated every where except at the cardiac end. Sir Everard Home found that fluids which had been drunk were chiefly contained in the cardiac portion, and that, if the body was examined early after death, the two portions of the stomach were frequently in fact divided by a muscular contrac-

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* Dr. Prout, in Thomson's *Annals of Philosophy*. 1819.

Dr. Wilson Philip, *An experimental Inquiry into the laws of the vital functions, &c.* 1817.

tion.* Dr. Haighton observed the same hour-glass contraction in a living dog, and remarked the peristaltic motion to be much more vigorous in the pyloric half.†

During digestion, the contents of the stomach acquire an acid of a volatile nature, and, on exposure to the air, one of a more fixed kind, probably the phosphoric.

In granivorous birds the food passes into the crop, and from this into a second cavity from which it enters the gizzard,—a strong muscular receptacle, lined by a thick membrane, in which, instead of having been masticated, it is ground by means of pebbles swallowed instinctively by the animal. Some graminivorous quadrupeds with divided hoofs have four stomachs, into the first of which the food passes when swallowed, and from this into the second. It is subsequently returned by portions into the mouth, chewed, and again swallowed, when, by a contraction of the openings of the two first stomachs, it passes over them into the third, and from this goes to the fourth. Some birds and insects also *ruminate.* The stomachs of some insects and crustacea contain teeth. Some zoophytes are little more than a stomach: others have several openings on the surface leading by canals that unite and run to the stomach,—a structure called by Cuvier, *mouth-root.* Between the most distinct kinds of stomach we see numerous intermediate varieties.

Vomiting cannot occur unless the stomach has the resistance of the diaphragm and abdominal muscles, or of something in their stead. Different persons have made the horrid experiment of giving an emetic to an animal and, after the abdominal muscles were cut away, observing how fruitless were all the efforts of the stomach to reject its contents till they applied their hands in place of these muscles, when the stomach, being forced by the diaphragm against the resistance, instantly accomplished

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* *Phil. Trans.* 1808.

† *Transactions of the Medical Society of London.* Vol. 2. 1788.

vomiting. M. Majendie * now claims to himself the establishment of this fact, but it was proved very many years ago. Dr. Haighton repeated such experiments with exactly M. Majendie's results upwards of thirty years since, and in England we have thought the question set at rest.†

* *Précis Elémentaire.* T. ii. p.139. and his *Mémoire sur le Vomissement.* 1813.

† *Transactions of the London Medical Society.* Vol. 2. 1788.

SECT. XXIV.

OF THE PANCREATIC JUICE.

363. The chyme, after passing the pylorus, undergoes new and considerable changes in the duodenum* —a short but very remarkable portion of the intestines, before the nutrient chyle is separated. To this end, there are poured upon it various secreted fluids, the most important of which are the bile and pancreatic juice.

364. Of these we shall treat separately, beginning with the pancreatic fluid, because it is closely allied both in nature and function to the saliva and gastric juice already mentioned.

365. Although it is with difficulty procured pure from living and healthy animals, all observations made in regard to it establish its close resemblance to the saliva. At the present day, it would scarcely be worth while to mention the erroneous hypotheses of F. Sylvius† and his followers—R. De Graaf,‡ F. Schuyl,§ and others, respecting its supposed acrimony, long since ably refuted by the celebrated Pechlin,|| Swammerdam,** and

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* Laur. Claussen, *De Intestini Duodeni situ et nexu.* Lips. 1757. 4to. Reprinted in Sandifort's *Thes.* Vol. iii. And the same celebrated Leyden Professor's *Tabulæ Intestini Duodeni.* LB. 1780. 4to.

† *De Chyli a fæcibus secretione.* LB. 1659. 4to.

‡ *De succi Pancreatici Natura et Usu.* ib. 1664. 12mo.

§ *Pro Veteri Medicina.* ib. 1670. 12mo.

|| *De Purgantium Medicamentorum Facultatibus.* ib. 1672. 8vo.

** *Observationum Anatomicarum Collegii privati Amstelodamens.* P. ii. *in quibus præcipue de piscium pancreate ejusque succo agitur.* Amst. 1673. 12mo.

Brunner,* unless they afforded a salutary admonition, how fatal the practice of medicine may become, if not founded on sound physiology.

366. The source of this fluid is similar to that of the saliva. It is the *pancreas*†—by much the largest conglomerate gland in the system, excepting the breasts, and extremely analogous to the salivary glands in every part of its structure, even in the circumstance of its excretory ducts arising by very minute radicles and uniting into one common duct, which is denominated, from its discoverer, Wirsüngian.

This duct penetrates the tunics of the duodenum, and supplies the cavity of this intestine with a constant stillicidium of pancreatic juice.

367. The excretion of this fluid is augmented by the same causes which affect that of the saliva;—pressure and stimulus.

By the former it is emulged, whenever the stomach lies in a state of repletion upon the pancreas.

By the latter, when fresh and crude chyme enters the duodenum and the bile flows through the opening common to it and the pancreatic fluid.

368. Its use is to dissolve the chyme, especially if imperfectly digested in the stomach, and at all times, by its great abundance, to assimilate the chyme more to the nature of the fluids and render it fitter for chylification.

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* *Experimenta nova circa pancreas.* Amst. 1683. 8vo.

† Santorini, *Tab. Post.* xiii. fig. 1.

SECT. XXV.

OF THE BILE.

369. The bile is secreted by the *liver* *—the most ponderous and the largest of all the viscera, especially in the fœtus,† in which its size is inversely as the age. The high importance of this organ is manifested, both by its immense supply of blood-vessels and their extraordinary distribution, as well as by its general existence. It is not less common to all red-blooded animals than the heart itself.

370. The substance of the liver is peculiar, easily distinguished at first sight from that of other viscera, of well-known colour and delicate texture,‡ supplied with numerous nerves,§ lymphatics (most remarkable on the surface),|| biliferous ducts, and, what these ducts

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* Eustachius, tab. xi. fig. 3, 4. Ruysch, *Thes. Anat.* xii. tab. iv. Santorini, *Tab. Posth.* xi.

† J. Bleuland, *Icon hepatis fœtus octimestris.* Traj. ad Rhen. 1789. 4to.

F. L. D. Ebeling, *De Pulmonum cum hepate antagonismo.* Goett. 1806. 8vo.

‡ In which, however, Autenreith discovers two substances, the one medullary and the other cortical. *Archiv. für die Physiol.* T. vii. p. 299.

§ Walter, tab. iv.

|| Maur. v. Reverhorst, *De motu bilis circulari ejusque morbis.* tab. i. fig. 1, 2.

Ruysch, *Ep. problemat.* v. tab. vi.

Werner and Feller, *Descriptio vasor. lacteor. atque lymphaticor.* Fascic. i. tab. iii. et iv. although Fr. Aug. Walter finds fault with these plates. *Annot. Academic.* p. 191 sq.

Mascagni. tab. xvii. xviii.

arise from, blood-vessels,* which are both very numerous and in some instances very large, but of different descriptions, as we shall state particularly.

371. The first blood-vessel to be noticed is the *vena portarum,* whose dissimilarity from other veins, both in its nature and course, was formerly hinted at. (97) Its trunk is formed from the combination of most of the visceral veins belonging to the abdomen, is supported by a cellular sheath called the capsule of Glisson,† and, on entering the liver, is divided into branches which are subdivided more and more as they penetrate into the substance of the organ, till they become extremely minute and spread over every part. Hence Galen compared this system to a tree whose roots were dispersed in the abdomen and its branches fixed in the liver. ‡

372. The other kind of blood-vessels belonging to the liver, are branches of the *hepatic artery,* which arises from the cœliac, is much inferior to the vena portæ in size and the number of its divisions, but spreads by very minute ramifications throughout the substance of the organ.

373. The extreme divisions of these two vessels terminate in true veins, which unite into large venous trunks running to the *vena cava inferior.*

374. These extreme divisions are inconceivably minute and collected into very small glomerules,§ which

* Haller, *Icones Anat.* Fascic. ii. tab. iii.

† Glisson, *Anatomia Hepatis.* p. 305 sq. 1659.

‡ *De Venarum Arteriarumque dissectione.* p. 109. Opera. Basil. 1562. cl. i.

§ Nest. Maximeow. Ambodick, *De Hepate.* Argent. 1775. 4to.

deceived Malpighi into the belief that they were glandular acini, hexagonal, hollow, and secretory.*

375. From these glomerules arise the *pori biliarii*—very delicate ducts, secreting the bile from the blood, and discharging it from the liver through the common hepatic duct, which is formed from their union.

376. It has been disputed whether the bile is produced from arterial or venous blood.

Although the former opinion† is countenanced by the analogy of the other secretions which depend upon arterial blood, nevertheless more accurate investigation proves that the greater part, if not the whole, of the biliary secretion is venous.

With respect to arguments derived from analogy, the vena portæ, resembling arteries in its distribution, may likewise bear a resemblance to them in function. Besides, the liver is analogous to the lungs, in which the great pulmonary vessels are intended for their function and the bronchial arteries for their nourishment; and if we are not greatly mistaken, the use of the hepatic artery is similar. We would, however, by no means completely deny its importance in the secretion of bile, but must regard it as inconsiderable, adventitious, and not well established. (A)

377. The *bile* flows slowly and regularly along the hepatic duct. The greater portion runs constantly through the ductus communis choledochus into the duodenum, but some passes from the hepatic into the *cystic duct*, and is received by the gall-bladder, where

* *De viscerum structura*. p. ii. Lond. 1669.

† This has lately found an advocate in Rich. Powel, *On the Bile and its Diseases*. Lond. 1801. 8vo.

it remains for a short period and acquires the name of *cystic bile.**

378. The *gall-bladder* is an oblong sac, nearly pyriform, adhering to the concave surface of the liver, and consisting of three coats.

The *exterior*, completely covering it, derived from the peritonæum.

The *middle*, called nervous, as in the stomach, intestines, and urinary bladder, the source of its firmness and tone.

The *interior*,† somewhat like the inner coat of the stomach, (359) containing a net-work of innumerable blood-vessels, abounding in mucous glands,‡ and marked by rugæ,§ which occasionally have a beautifully cancellated appearance.

379. Its cervix is conical, terminates in the cystic duct, is tortuous, and contains a few falciform valves.‖

380. The bile which has passed into the gall-bladder is retained until, from the reclined or supine posture of the body, it flows down from it spontaneously, or

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* In cows and other brutes there are peculiar *hepato-cystic* ducts, which convey the bile directly from the liver to the gall-bladder. *Observ. anat. coll. privati Amstel.* P. 1. Ams. 1667. 12mo. p. 16. fig. 7. Also, Perrault, *Essays de Physique*. T. i. p. 339. tab. ii.

Some have inconsiderately allowed them also in the human subject: v. c. De Haen, *Ratio med. cont.* P. ii. p. 46 sq. tab. x. fig. 1.

Also Pitschell, *Anat. und chirurg. Anmerk.* Dresd. 1784. 8vo. tab. i.

Consult among many, R. Forsten, *Quæst. select. physiolog.* Lugd. Batav. 1774. 4to. p. 22.

† Ruysch, *Epist. problem. quinta.* Tab. v. fig. 3.

‡ Vicq-d'Azyr, *Œuvres.* T. v. page 343.

§ Casp. Fr. Wolff, *Act. Acad. Scient. Petropol.* 1779. P. ii.

‖ Caldesi, *Osservaz. intorno alle Tartarughe.* Tab. ii. fig. 10.; but especially Wolff, lately recommended, l. c. P. i. tab. vi. Also, Fr. Aug. Walter, l. c. tab. i.

is squeezed* out by the pressure of the neighbouring jejunum, or ileum, or of the colon when distended by fæces.

The presence of stimuli in the duodenum may derive the bile in that direction.

The great contractility of the gall-bladder, proved by opening living animals and by pathological phenomena, although it is not true irritability (301), probly assists the discharge of bile, especially when this fluid has, by retention, become very stimulating.

381. For the cystic bile, though very analogous to the hepatic, (377) becomes more concentrated, viscid, and bitter, by stagnation in the gall-bladder; the cause of which is, in all probability, the absorption of its more watery parts by the lymphatic vessels.†

382. Our attention must now be turned to the bile itself—a very important fluid, respecting the nature and use of which there has been for these thirty years more controversy than about any other fluid.

The cystic bile, being more perfect and better calculated for examination, will supply our observations.

383. Bile taken from a fresh adult subject, is rather viscid, of a brownish green colour,‡ inodorous, and, if compared with that of brutes, scarcely bitter.

384. Its constituent parts obtained by chemical analysis, are, besides a large proportion of water, albu-

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* Caldani, *Institut. Physiolog.* p. 364 sq. Patav. 1778. 8vo.

† Reverhorst, l. c. tab. ii. fig. 4.
Ruysch, l. c. tab. v. fig. 4.
Werner and Feller, l. c. tab. ii. fig. 5.
Mascagni, tab. xviii.

‡ On the variety of colour in the bile, consult Bordenave, *Analyse de la Bile*, in the *Mém. Présentés*, &c. T. vii. p. 611, 617.

men, resin, soda,* partly united with phosphoric, sulphuric, and muriatic, acid, a small portion of phosphate of lime and iron, and a variable quantity of a remarkable and peculiar yellow matter.†

385. The composition of the bile varies greatly both from the proportion of its parts, particularly of the albuminous and resinous, differing under different circumstances, and also from the addition of other constituents, during morbid states, especially of adipocerous substances, which give origin to most biliary calculi; for these consist either of it alone, or of it combined with the yellow substance just mentioned. (B)

386. The nature of the bile is not saponaceous and capable of effecting a combination between water and oils, as Boerhaave supposed, but which opinion the excellent experiments of Schröder,‡ who was formerly of this university, both confirmed and extended by other physiologists,§ have disproved. It even decomposes a combination of those substances.||

387. The important and various use of the bile in chylification is self-evident.

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* Joachim Ramm, *De alcalina bilis natura.* Jen. 1786. 4to.
J. Fr. Straehl, *De bilis natura.* Gotting. 1787. 8vo.
W. M. Richter, *Experimenta circa bilis naturam.* Erlang. 1788. 4to.

† Thenard, *Mémoires de la Societé d'Arcueil.* T. i.

‡ *Experimenta ad veriorem cysticæ bilis indolem explorandam capta.* Sect. i. Gotting. 1764. 4to.

§ It will be sufficient to quote a few of a large number:—
Spielmann, *De natura bilis.* Argent. 1767. 4to.
Ger. Gysb. ten. Haaf, *De bile cystica.* LB. 1772. 4to.
G. Chr. Utendörfer, *Experim. de bile.* Argent. 1774. 4to.
Dav. Willink, *Consideratio bilis.* LB. 1778. 8vo.
Seb. Goldwitz, *Neue Vers. zu einer wahren Physiol. der Galle.* Bamberg. 1785. 8vo.

|| Marherr, *Prælect. in* Boerhaavii *institut.* Vol. i. p. 463, 478. 1785.

In the first place, it gradually precipitates the fæces, and separates the milky chyle from the mixed and equable pultaceous chyme, while this is passing through the tract of the small intestines, after being propelled from the stomach into the duodenum and diluted by the pancreatic juice.*

It separates itself into two portions, the one serous, the other resinous. The latter combines with the fæces, tinges them, and is discharged with them; the former is probably mixed with the chyle and carried back to the blood. (C)

The bile seems to act as a stimulus to the peristaltic motion† of the intestines.

We shall omit other less probable uses assigned to the bile, v. c. of exciting hunger by regurgitating into the stomach,—a circumstance which I think can hardly happen during health.

NOTES.

(A) Two instances have occurred in London, of the vena portæ running, not to the liver, but immediately to the vena cava inferior. The bile must have been secreted entirely from the blood of the hepatic artery. One of these is described by Mr. Abernethy, ‡ and the other is mentioned by Mr. Lawrence. §

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* Chr. L. Werner, (Præs. Autenreith) *Experimenta circa modum, quo chymus in chylum mutatur*. Tubing. 1800. 8vo.

† G. Fordyce, *On the digestion of food*. p. 70.

‡ *Philos. Trans.* Vol. lxxxiii.

§ *Medico-Chirurgic. Trans.* Vol. iv. p. 174.

(B) Berzelius* states, that bile contains alkali and salts in the same proportion as the blood, and that no resin exists in it, but "a peculiar matter, of a bitter and afterwards somewhat sweet taste, which possesses characters in common with the fibrin, the colouring matter, and the albumen of the blood." This forms, with an excess of acid, a perfectly resinous precipitate. What has been considered albumen in the bile, Berzelius regards as the mucus of the gall-bladder.

Bile contains of

Water	907.4
Biliary matter	80.0
Mucus of the gall bladder dissolved in the bile	3.0
Alkalies and salts common to all secreted fluids	9.6
	1000.0 †

(C) During the precipitation of the chyle and the decomposition of the bile, a gaseous product is usually evolved, the mass becomes neutral, and traces *of an albuminous principle* commence, strongest at a certain distance from the pylorus,—below the point at which the bile enters the intestine, and gradually fainter in each direction. On mixing bile with chyme out of the body, a distinct precipitation takes place, and the mixture becomes neutral; but the formation of an albuminous principle is doubtful, probably from the want of the pancreatic fluid.‡

It is wonderful that in jaundice, when no bile is seen in the fæces, and according to Dr. Fordyce even in artificial obstruction of the choledochus by ligature, nutrition continues. Life and health are said to continue after the removal of the organ next to be considered,—the spleen. We know little of the compensating resources of nature.

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* *Animal Chemistry.* p. 65.

† *Med. Chirurg. Trans.* Vol. iii. p. 241.

‡ Dr. Prout in Thomson's *Annals of Philosophy.* 1819.

SECT. XXVI.

OF THE FUNCTION OF THE SPLEEN.

388. THE *Spleen** lies to the left of the liver, with which it has considerable vascular communications; its figure is oblong;† it applies itself to the contiguous viscera, and is liable to great varieties in point of form, number, &c.‡

389. Its colour is livid, its texture singular, soft, easily lacerated, and therefore surrounded by two membranes, the interior of which is proper to the spleen and the exterior derived from the omentum.

390. The situation and size of the spleen are no less various than its figure, and depend upon the degree of the stomach's repletion; for, when the stomach is empty and lax, the spleen is turgid; when the stomach is full, the spleen, being compressed, is emptied.

It undergoes a continual but gentle and equable motion, dependent upon respiration, under the chief instrument of which—the diaphragm, it is immediately situated.

391. Its texture was formerly supposed to be cellular,

* Ch. Drelincourt, the younger, has carefully collected and concisely related whatever was known up to his time, respecting the spleen, *De lienosis*, at the end of his father's Opuscula. Boerhaave's edition. p. 710 sq.

Also Chr. Lud. Roloff, *De fabrica et functione lienis*. Frf. ad Viadr. 1750. 4to.

† Walter, tab. iii. G.

Mascagni, tab. xiv. P.

‡ See Sandifort, *Natuur en genees-kundige Bibl.* Vol. ii. p. 345 sq.

and compared to the corpora cavernosa of the penis. This opinion was proved to be erroneous by more careful examination of the human spleen,* which consists entirely of blood vessels, of enormous size in comparison with the bulk of the organ. They are in fact proportionably more considerable than in any other part of the body.

392. The experiments of Wintringham demonstrate the great tenuity and strength of the coats of the splenic artery. It is divided into an infinite number of twigs, the terminations of which resemble pulpy penicilli and give rise to the splenic veins, which gradually unite into large, loose, and easily dilatable, trunks.

393. This immense congeries of blood vessels is connected and supported by a sparing cellular parenchyma, from which the absorbents arise. The trunks of these run along the lower surface of the spleen between the two coats just described.†

394. This loose structure of the spleen, easily becoming distended with blood, admirably confirms what we formerly remarked respecting the turgor of this organ (390). The congestion and slow return of the splenic blood, if the nature of the neighbouring organs is also taken into consideration, illustrates its peculiar properties, which may throw some light upon the function of this enigmatical viscus—the source of so much controversy.

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* Lobstein's Dissertation, *nonnulla de Liene sistens.* Argent. 1774. 4to.

† The singular and rather paradoxical opinions of Hewson, without doubt, a very superior man, respecting the functions of the spleen, whose lymphatic vessels he regards as excretory ducts, may be found in his posthumous work entitled *Experimental Inquiries.* Third edition. London. 1777. 8vo. C. ii. S. xlv sq. xcv sq.

395. The splenic blood is very fluid, coagulates with great difficulty, separates the serum from the crassamentum imperfectly, and is of a livid dark colour, like the blood of the fœtus. These circumstances clearly demonstrate the abundance in it of carbonaceous matter; which is likewise proved indisputably by an easy experiment. Whenever I have exposed sections of a recent spleen to oxygen gas, they have acquired a very bright red colour, while the air, losing its oxygen, has become impregnated with carbon.

396. But since the spleen is the only organ of that description quite destitute of an excretory duct excepting its veins which run ultimately to the liver, its function is probably subservient to that of the latter. This opinion has appeared strengthened by the observation, that in animals deprived of their spleen,—an experiment frequently made from the most remote period,* the cystic bile is sometimes found pale and inert.

397. At least twenty hypotheses have been framed respecting the use of the spleen. Two more have been lately advanced, both supposing a connection between the spleen and *stomach,* but the one† regarding the spleen as a diverticulum to the blood destined to form the *gastric juice;* (A) the other,‡ supported by excellent arguments and experiments, making the spleen to receive a great portion of our *drink* from the *cardiac* extremity of the stomach, so that these may pass through a short cut, hitherto unknown, from the stomach to the spleen, and thus into the mass of blood.

* J. H. Schulze, *De splene canibus exciso.* Hal. 1735. 4to.

† Vinc. Malacarne, *Memorie della soc. italiana.* T. viii. P. 1. p. 233.
A. Moreschi, *Del vero e primario uso della milza.* Milan. 1803. 8vo.

‡ Ever. Home, *Philos. Trans.* 1808.

The latter hypothesis, if a few objections were removed,* would be much the most plausible of any hitherto constructed. (B)

NOTES.

(A) This opinion was proposed a century ago, by Dr. Stukely, Fellow of the Royal College of Physicians, London.†

(B) Sir Everard Home's friends having, among other experiments, passed a ligature around the pyloric extremity of the stomach of a dog, injected into this receptacle a solution of rhubarb; and, on killing the animal some few hours afterwards, none of the absorbents of the stomach were found distended, nor could any trace of rhubarb be detected in the liver, but evident traces existed in the spleen and in the urine. When fluids had

* For instance, the size of the spleen in those warm blooded animals which never drink, or in bisulcous animals whose spleen adheres to the ruminant stomach receiving the crude food only, but never the drink, which is prevented from entering it by the well-known mechanism of a semicanal running from the œsophagus to the omasum.

† *Of the Spleen, its description and history, uses and diseases, particularly the vapors with their remedy. Being a lecture read at the Royal College of Physicians.* By Wm. Stukely, M.D. C.M.L. and S.R.S. London. 1722. folio. Considering the spleen to consist entirely of complications and inosculations of arteries, veins, and cells, nerves, and (as Malpighi asserted) "a muscular net-work of fibrillæ," he supposed that it contracted and propelled its blood through the splenic vessels into those of the stomach, when this organ required a larger supply during digestion. p. 37. He maintained likewise that it accelerated the motion of the blood in the mesenteric veins when the circulation in the vena portæ was sluggish, and that it answered various other purposes.

Dr. Haighton (Lectures at Guy's Hospital), and Mr. Saumarez (*New System of Physiology*) have explained its operation as a diverticulum in a very different manner. When the stomach is full, the compression experienced by the spleen impedes its circulation, and the blood makes its way the more copiously into the arteries of the stomach, liver, &c.

been drunk, the spleen was turgid and exhibited cells full of a colourless liquid, which were at other times collapsed and almost imperceptible,—a circumstance rendering it unlikely that the spleen is diminished in bulk by the distention of the stomach. During the distention of the spleen, when the pylorus was not tied, the rhubarb appeared more strongly in the blood of the splenic than in that of other veins. If coloured solids without fluids were introduced into the stomach, the cells of the spleen were not distended, nor did this organ or its veins give more signs of the colouring matter than others.

SECT. XXVII.

OF THE FUNCTION OF THE OMENTUM.

398. The omentum gastro-colicum or magnum * (to distinguish it from the parvum or hepato-gastricum),† is a peculiar process of peritonæum, arising immediately from the peritonæum of the stomach.

399. Although there are innumerable continuations of the peritonæum in the abdomen, and every abdominal viscus is so covered by it that on opening the abdomen nothing is found destitute of that membrane, nevertheless, it is afforded in different ways, which may be reduced to classes.

Over some the peritonæum is merely extended, or it affords to them only a partial covering, as is the case with respect to the kidneys, rectum, urinary bladder, and in some measure with respect to the pancreas and gall-bladder.

To some which project into the cavity of the abdomen although adhering to its parietes, it affords a covering for the greater part of their surface; v. c. to the liver, spleen, stomach, uterus, and the testes of the very young fœtus.

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* Eustachius, tab. ix.

Haller, *Icones. anat.* fasc. i. tab. iv. K. M. and the Appendix Colica, which he himself investigated at Göttingen in 1740. ib. R.

Rob. Steph. Henry, *Descript. omenti c. icone nova.* Hafn. 1748. 4to.

† Eustachius, tab. x. fig. 1. G. H.

Haller, l. c. Q.

The intestinal tube, with the exception of the rectum, projects so much into the cavity of the abdomen, that it is, as it were, suspended in loose processes of the peritonæum, called mesentery and mesocolon: the broad ligaments of the uterus are similar to these.

400. The longest and most remarkable process of peritonæum, is the *omentum*—a large, empty, delicate, sac, hanging from the large curvature of the stomach, extended over the greater part of the small intestines, applying itself closely to their convolutions, and in some measure insinuating itself into their interstices.

401. Besides the blood vessels seen upon the omentum, it is marked by fatty striæ or bands, every where reticulated (whence the german name (Netzhaut) of this membrane), which in corpulent persons increase occasionally to a large and even dangerous size, and by means of which the whole omentum is lubricated by an adipose halitus.

402. On the latter circumstance depends the use commonly ascribed to the omentum,—of lubricating the intestines and assisting their continual movements: this also appears the use of those analogous small bursæ which are found * in such numbers about the rectum † and colon.‡ The omentum also prevents the adhesion of the intestines to the peritonæum, and the consequent impediment to the functions of the primæ viæ.

403. There is another two-fold office attributed with

* I have lately seen similar appendices on the peritonæal covering of an uterus unimpregnated, but which had formerly been pregnant.

† Walter, tab. ii. *m. m. m.*

‡ Bidloo, *Anatomia hum. corporis.* tab. xxxix. fig. 6. C. C. C. D. D. D.

great probability to the omentum,* viz. that of facilitating the dilation of the viscera to which it is contiguous, and of acting as a diverticulum to their blood during their state of vacuity.

404. If we reflect on the singular structure of the omentum parvum or hepato-gastricum especially, we may be inclined to believe that there is another and principal office attached to it, unknown at present, and discoverable by comparative anatomy.

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* v. Chaussier, *Mémoires de l'Acad. de Dijon.* 1784. Semestr. ii. p. 95.

SECT. XXVIII.

OF THE FUNCTION OF THE INTESTINES.

405. The intestinal tube, over which the omentum is extended, and which receives the chyme to elaborate it farther (362, 363) and separate the chyle from the fæces, is divided into two principal portions—the small and large intestines, of whose functions we shall speak separately.

406. The small* intestines are again divided into three: the duodenum, jejunum, and ileum.

The first is named from its usual length.

The second from generally appearing collapsed and empty.

The third from its convolutions: it is the longest of the three, fuller, and, as it were, inflated, and sometimes resembling the large intestines by the appearance of bullæ.

407. The coats of the small intestines correspond with those of the stomach (354).

The *external* is derived from the mesentery.

The *muscular* consists of two orders of fibres: the one longitudinal, interrupted, external, and found especially about the part opposite the mesentery; the other, annular and falciform, possessing the power of narrow-

* Chr. Bernh. Albinus, *Specimen anat. exhibens novam tenuium hominis intestinor. descriptionem.* LB. 1724. 8vo.

ing the canal, while the former shortens it. Upon both depends the very great and permanent irritability of the intestines, formerly mentioned (300).

The *nervous* coat is condensed cellular membrane, easily reduced by handling or more particularly by inflation, into a spumous tela;* in it the intestinal blood-vessels run to the mesenteric † in a beautifully arborescent form;‡ the intestines, no less than the stomach, are indebted to it for their tenacity and strength.

The interior, lined by its delicate epithelium, and deserving the name of *villous* in the small intestines more than in any other part of the canal, forms, in conjunction with the inner surface of the former coat, here and there, undulated ridges and rugous plicæ, which, in dried and inflated intestines, resemble the blade of a scythe, and are termed the valvulæ conniventes or Kerkringhianæ.§

408. The *villi,* which are innumerable ‖ upon the inner surface of the intestines, and whose beautiful and minute vascular structure was first carefully investigated, though described with exaggeration, by Lieberkühn,** may be, perhaps, compared, while destitute

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* B. S. Albinus, *Annotat. Academ.* L. ii. tab. iv. fig. 1, 2.

† Eustachius, tab. xxvii. fig. 2. 4.

‡ B. S. Albinus, *Dissert. de arteriis et venis intestin. hominis,* with coloured plates. LB. 1736. 4to. Also his *Annotat. acad.* L. iii. tab. i. ii.

§ Kerkring, *Spicilegium anatomicum.* tab. xiv. fig. 1, 2.

‖ He estimated their number, in the small intestines of an adult, to be about 500,000.

** *De fabrica et actione villorum intestinor. tenuium hominis.* LB. 1745. 4to.

J. Bleuland, *Descriptio vasculorum intestinorum tenuium hominis.* Ultraj. 1797. 4to.

R. A. Hedwig, *Disquisitio ampullarum Lieburkühnii.* Lips. 1797. 4to.

C. A. Ruof chyle, to little loose pendulous bags, internally soft and spongy; but, when distended with chyle, they have the appearance of a morel.

409. The base of these villi is surrounded by innumerable *glandular follicles*, adhering chiefly to the nervous coat, and opening into the intestinal canal by a very small orifice, through which they discharge the mucus that lines the whole tract of the intestines.

These are distinguished into three orders. The Brunnerian, largest, distinct, found in most abundance in that part of the duodenum which is contiguous to the pylorus.* The Peyerian, smaller, aggregated, found chiefly at the termination of the small intestines,—about the valve of the colon.† Lastly, the Lieberkühnian, the smallest, said to be distributed in the proportion of about eight to each villus.‡ The two former orders are so inconstant, that I am inclined to consider the view given of them in the plates alluded to, as morbid;§ for I have more than once been unable to discover the slightest trace of fungous papillæ with a single pore, in the small intestines of healthy adults; while, on the contrary, in *aphthous* subjects, I have found nearly the

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C. A. Rudolphi, *Anatomisch-physiologische Abhandlungen.* Berlin. 1802. 8vo. p. 39.

* J. Conr. a Brunn, *Glandulæ duodeni s. pancreas secundarium.* Frf. 1715. 4to. fig. 1.

† J. Conr. Peyer, *De Glandulis intestinorum.* Scafhus. 1677. 8vo. especially fig. 3.

‡ Lieberkühn, l. c. p. 17. tab. iii.

§ The eminent Rudolphi thinks differently, l. c. p. 212.

whole intestinal tube beset with them in infinite numbers, both solitary and aggregated.*

410. As the gastric juice is poured into the stomach, so an *enteric* or *intestinal fluid* is poured into the small intestines, demonstrated, among other ways, by the common experiment, first, I believe, instituted by Pechlin.† It is probably of a nature similar to the gastric liquor, but an accurate investigation of it is a physiological desideratum. I can say nothing respecting its quantity, but the estimation of Haller is certainly exaggerated,—at eight pounds in the twenty-four hours. (A)

411. The intestines agree with the stomach in this particular, that they have a similar, and, indeed, a more unquestionable, or, at least, a more lively, *peristaltic action,*‡ which occurs principally when the chymous pulp enters them. This it agitates by an undulatory constriction of different parts of the canal, and propels from the duodenum towards the large intestines. Although the existence of an antiperistaltic motion, causing a retrograde course to their contents, cannot be disproved, it is in health much weaker, and less common and important, than the former.

412. By these moving powers and by these solvents which are afforded by means of secretion, the chyme undergoes remarkable changes. § In the jejunum it

* These intestinal *aphthæ* exactly resemble those tubercles which Sheldon, whom we shall presently quote, exhibits (Tab. 1.) as small ampullæ full of chyle.

† *De purgantium medicamentor. facultat.* p. 509. tab. iv.

‡ Benj. Schwartz, *De vomitu et motu intestinorum.* LB. 1745. 4to.

J. Foelix, *De motu peristaltico intestinorum.* Trevir. 1750. 4to.

§ Consult the excellent observations and experiments of A. E. Ferd. Emmert, *Archiv für die Physiologie.* T. viii. p. 145.

becomes a more liquid pulp, equally mixed, of a grey colour, and acidulous odour: in the ileum it begins to separate into two parts—into the fæces, of a pale, yellowish, brown, colour,* and nauseous smell—and the genuine chyle, swimming upon the former, extracted from the chyme, separated by the bile from the fæces, and destined for absorption by the lacteal vessels, as we shall find in the next section (A). At present, we shall enquire what course is taken by the fæces.

413. These, after becoming more and more inspissated in their long course through the ileum, have to overcome the valve of the colon and pass into the large

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* We formerly (387) remarked, that the bilious colour of the fæces arose from the excrementitious part of the bile. In the jejunum, the bile being undecomposed and mixed with the equable pulp of the intestines, and consequently diffused and diluted, cannot exhibit its true colour. But after its separation into two parts, the excrementitious portion, mixed with the precipitated fæces, and, as it were, again concentrated, now discovers its original colour, and imparts it to the fæces.

C. F. Wolff (*Act. Petropolit.* 1779. P. ii. p. 245.) entertains a different opinion in regard to the cause of the bilious colour of the fæces contained in the ileum. He conceives that an addition of bile occurs near the extremity of the jejunum, *by exhaling from the gall-bladder and penetrating this part of the intestine and its contents.* This bile differing, perhaps, in its nature, from the bile of the choledochus, and not being mixed with the fæces as the latter is with the chyme, retains its colour through all the remaining tract of the intestines and continues pure bile.

But, besides our being able easily to explain why this colour is not observable before the decomposition of the chyme and bile, it is extremely doubtful whether, during life and health, any exhalation can occur from the gall-bladder and penetrate the intestine. For in subjects recent and scarcely cold, the intestines are but slightly tinctured with bile, although they are dyed with it very deeply and extensively after a lapse of some hours or days, i. e after the coats of the gall-bladder have lost their tone and become incapable of preventing the transudation of their contents.

intestines. To facilitate this, the extremity of the ileum is lubricated very abundantly by mucus.

414. The *valve of the colon*,* or, as it may deservedly be termed after its discoverer, the valve of Fallopius,† is a short process or continuation of the portion of the ileum that penetrates into the cavity of the large intestine and is surrounded by it. Its external lips, while a neighbouring fold of the large intestine at the same time projects considerably, are composed,‡ not like other similar folds, merely of the interior and nervous coats, but of fibres from the muscular coat. Hence it performs the double office of preventing the passage

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* Haller, *De valvula coli.* Gotting. 1742. 4to. reprinted in his *Oper. minor.* T. i. p. 580 sq.

T. Mich. Röderer, *De valvula coli.* Argent. 1768. 4to.

† The various opinions respecting the discoverer of this remarkable valve are well known. Haller's *Elementa.* T. vii. P. 1. page 142, may be consulted on this point.

In the mean time I am certain that, long before the period at which its discovery is in general dated, it was accurately known to that immortal anatomist Gabr. Fallopius. In our university library there is a manuscript of Fallopius, containing, among other things, his *anatomy of the monkey*, in which is an account of the structure and use of the valve of the colon, delivered in a public demonstration at Padua, Feb. 2. 1553. in the following words: "*The use of the cæcum in the monkey, is to prevent the regurgitation of the food during progression on all fours. This is proved by the circumstance of water or air, thrown into the rectum, reaching the cæcum, but not passing beyond the large intestines. But, if impelled from above, it passes into them. The reason is this,—at the insertion of the ileum are two folds, which are compressed by inflation and repletion, as occurs in the heart, and prevent retrogression; wherefore, in man, clysters cannot pass and be rejected through the mouth, unless in a weak and diseased state of the intestines.*"

‡ A view of a recent and entire valve is exhibited by B. S. Albinus in his *Annotat. Academ.* L. iii. tab. v. fig. 1. and overcharged by inflation and drying, in Santorini's Posthumous Tables. xiv. fig. 1, 2.

of too great a quantity of fæces into the large intestines, and regurgitation into the small.

415 The large intestines, divided like the small into three parts, commence by the *cæcum* (which has a *vermiform process* whose use in man is unknown)*, and afford a very ample receptacle, in which the fæces may be collected and retained till the period of their discharge arrives.

416. They exceed the small intestines in thickness and strength, as well as in capacity. The muscular coat has this peculiarity—that its longitudinal fibres, excepting at the extremity of the rectum, are collected into three bands, called ligaments of the colon;† and the intestines themselves are divided into a kind of prominent cells. The inner coat is not so beautifully flocculent as in the small intestines, but more similar to that of the stomach.

417. Their peristaltic motion is much fainter than that of the small intestines. On the other hand, they experience to a greater degree the pressure of the abdominal parietes, to which the whole length of the *colon* is contiguous.

418. They gently propel the fæces into the *rectum*, which thus becomes internally stimulated to discharge its contents. The discharge is facilitated by the absence of transverse rugæ, and especially by the great quantity of mucus at the extremity of the bowels.

419. It is principally effected by the pressure of

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* Lieberkühn, *De valvula coli et usu processus vermicularis.* LB. 1739. 4to. J. Vosse, *De intestino cæco ejusque appendice vermiformi.* Gotting. 1749. 4to.

† Eustachius, tab. x. fig. 2, 4, 5.

the abdomen downwards, overcoming the resistance of the os coccygis and of both sphincters, the inner of which is a remarkable bundle of circular fibres, the outer, a truly cutaneous muscle. After the excretion, the effort of the abdomen having ceased, the levator ani chiefly retracts the intestine, which is again closed by its sphincter.*

NOTES.

(A) Pechlin's experiment was simply to include a portion of intestine between two ligatures, so that the fluid secreted into the canal might be collected.

(B) A great part of the chyle is generally formed and absorbed before the digested mass reaches the ileum.† On arriving in the large intestines, the mass undergoes fresh changes, at present unexplained, and is converted into excrement. Here it is that the true *succus entericus* must be poured forth.

The gas of the stomach contains, besides azote and carbonic acid gas, oxygen, and very little hydrogen; while that of the small intestines contains, besides the two former gases, no oxygen and abundance of hydrogen: that of the large intestines has less hydrogen and carbonic acid, and likewise no oxygen. Little or no gas is found in the stomach during chymification.

The following are the results of M. M. Majendie's and Chevreuil's analysis of the gases of the alimentary canal.

In the stomach of a man just executed,—

* All these parts may be seen as they exist in each sex, in Santorini's Posth. Tables. xvi. and xvii.

† Dr. Prout, Thomson's *Annals of Philosophy.* 1819.

Oxygen - - - -	11,00
Carbonic acid - - -	14,00
Pure hydrogen - - -	3,55
Azote - - - -	71,45
	100,00

In the small intestines of a subject, four and twenty years of age, who had eaten, two hours before execution, bread and Gruyère cheese and drunk eau rougie,—

Oxygen - - - -	0,00
Carbonic acid - - -	24,39
Pure hydrogen - - -	55,53
Azote - - - -	20,08
	100,00

——— twenty-three years of age, who had eaten the same food, and was executed with the former,—

Oxygen - - - -	0,00
Carbonic acid - - -	40,00
Pure hydrogen - - -	51,15
Azote - - - -	8,85
	100,00

——— twenty-eight years of age, who, four hours before execution, had eaten beef, bread, lentils, and drunk red wine,—

Oxygen - - - -	0,00
Carbonic acid - - -	25,00
Pure hydrogen - - -	8,40
Azote - - - -	66,60
	100,00

In the large intestines of these three criminals, were found,—

Oxygen - - - - - -	0,00
Carbonic acid - - - - -	43,50
Carburetted hydrogen and some traces of sulfuretted hydrogen -	5,47
Azote - - - - - -	51,03
	100,00

Oxygen - - - -	0,00
Carbonic acid - - -	70,00
Hydrogen and pure carburetted hydrogen - - -	11,06
Azote - - - -	18,04
	100,00

The gas of the cæcum and rectum of the third was examined separately. Cæcum,—

Oxygen - - - -	0,00
Carbonic acid - - -	12,50
Pure hydrogen - - -	7,50
Carburetted hydrogen - -	12,50
Azote - - - -	67,50
	100,00

Rectum,—

Oxygen - - - -	0,00
Carbonic acid - - -	42,86
Carburetted hydrogen - -	11,18
Azote - - - -	45,96
	100,00

Some traces of sulfuretted hydrogen appeared upon the mercury before the last analysis was commenced.

Berzelius finds human excrement to consist of

Water - - - - -	73,3
Remains of vegetable and animal matter - - - -	7,0
Bile - - - - -	0,9
Albumen - - - -	0,9
Peculiar extractive matter -	2,7
Matter composed of altered bile, resin, animal matter, &c. -	14,0
Salts - - - - -	1,2
	100,0

The excrements of brutes have been analysed, but not to an extent capable of affording general views.

SECT. XXIX.

OF THE FUNCTION OF THE ABSORBENT VESSELS.*

420. THE chyle, which we left in the ileum just separated from the fæces, must evidently be a mixture of different fluids. The proportion derived from the *secretions*—the saliva, bile, the gastric, pancreatic, and enteric, fluids, surpasses, without the least doubt, that which is derived from the aliment, although this cannot be accurately ascertained. Hence must be derived the solution of the problem,—how ingesta of such various kinds can be converted into the chyle—a fluid constantly of the same appearance, homogeneous, and of an animal nature.

421. The course of the chyle from the intestines to the blood, is through a part of the absorbent system, which we have hitherto only hinted at, but shall now speak of particularly. It is divided into four parts—lacteal, and lymphatic, vessels, conglobate glands, and the thoracic duct. Each of these will now fall under consideration.

422. It is certain that the lacteals originate among the villi of the internal coat of the intestines; but whether they are an immediate continuation of these villi, or merely connected with them by a cellular medium,

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* A very copious list of writers upon the absorbents will be found in Sömmering's work, *De morbis vasorum absorbentium corporis humani.* Francof. 1795. 8vo.

admits a question. I myself have never been able to trace them so far as to discover their immediate connections with the villi, but they appear to arise here and there in the coats of the intestines, by a conspicuous trunk, and we may conjecture that they take up the chyle from the cellular structure into which it is first drawn by the villi. This I have in fact observed repeatedly in puppies, after making them swallow a solution of indigo, according to the celebrated experiment of Lister,* an hour or two before opening them alive. (A)

423. The trunks just mentioned run some inches along the surface of the intestines, under the external coat, sometimes meandering in an angular course, before they reach the mesentery.

424. In their course through the mesentery they run into the mesenteric glands, of which there are two series. The one, nearer the intestines, dispersed, small, and resembling beans in shape; the other, nearer the receptaculum chyli, large, and aggregated.

425. Both appear nothing more than closely-compacted collections of lacteals, interwoven with innumerable blood-vessels,† and retarding the course of the chyle; to the end, perhaps, that it may be more intimately and perfectly assimilated to an animal nature, previously to its entrance into the thoracic duct and its mixture with the blood. (B)

426. It has been inquired whether lacteals exist also in the large intestines, and their existence has been

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* *Philos. Trans.* No. 143, compared with No. 275.

† Boerhaave and Ruysch, *De fabrica glandularum opusculum.* LB. 1722. 4to. p. 81.

contended for from the effects of particular injections, nutrient, inebriating, &c. and also from the circumstance that the fæces, if retained for any length of time, become hard and dry. Although these arguments do not demonstrate the absorption of genuine chyle below the valve of Fallopius, nevertheless it is rendered probable by the visible existence of an abundance of lymphatics, in the large intestines,* having the same structure and function with the lacteals; for these absorb lymph from the intestines,† during the absence of chyle.

But the very different structure of the internal coat of the large intestines from that of the villous coat of the small, strongly argues that they are not naturally intended to absorb chyle.

427. There is another question more important and difficult of solution,—whether all the chyle absorbed from the small intestines passes through the thoracic duct, or whether some enters the blood by more secret passages?

The latter opinion rests upon very unstable arguments. Thus the assertion of Ruysch,—that the mesenteric glands become, in advanced life, indurated and unfit for continuing their functions, was long since disproved; and affections of these glands, swellings, &c. are improperly called obstructions,‡ as the glands remain pervious, readily allowing a passage to quicksilver. The well-known phenomenon of tepid water,

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* Mascagni, Tab. xvi.

† See Nuck, *De inventis novis ep. Anatomica.* p. 146 sq.

‡ v. J. Rezia, *Specim. Observat. Anatomicar. et Pathologicar.* Ticini. 1784. 8vo. p. 18.

injected after death into the mesenteric veins, passing into the cavity of the intestines, has little weight with me in regard to a function which occurs during life; and much less weight can be allowed to the brass tube with two legs and two branches invented by Lieberkühn to prove the existence of these passages. (C) The assertion—that chyle has been seen in the mesenteric veins,* requires farther investigation and proof; so that I cannot believe that they carry any thing more than blood, very carbonised and destined for the formation of bile.† (D)

428. The ultimate trunks of the lacteals, arising, like the lymphatics, from the combination of a great number of small twigs,‡ unite into the *receptaculum* or *cisterna chyli,*—the appellation by which the lower and

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* Werner and Feller, l. c. p. 12 sq.

† There is a beautiful experiment which seems, at first sight, to favor the existence of these secret passages, and for which I am indebted to the eminent Leop. M. A. Caldani. In a lamb or kid, after hearty feeding, a ligature is placed upon the vein corresponding with our left subclavian, and another, particularly tight, upon the mesentery, at its origin near the lumbar vertebræ. The lacteals and lymphatics, between the ligatures, become very evident; and likewise the lymphatics ascending from the hind legs. At first, the lacteals between the intestines and constricted mesentary swell, but they soon subside and disappear.

This singular phenomenon, however, appears to me not owing so much to any secret passages for the chyle, as to a retrograde motion of it into the intestines; the valves, under these circumstances, not offering sufficient opposition. Vide B. Nath. Gottl. Schreger, *Fragmenta Anatomica et Physiologica.* Fasc. 1. Lips. 1791. 4to. p. 26.

Flor. Caldani, *Riflessioni sopra alcuni punti di un nuovo sistema de' vasi assorbenti, &c.* Padua. 1792. 8vo. p. 58.

And his uncle, commended above, Leop. M. A. Caldani, in his Commentary to be found in the *Memorie lette nell' Acad. di Padova.* 1804. 4to.

‡ Sheldon, l. c. Tab. v.

larger part of the *thoracic* or PECQUETIAN *duct* is distinguished.

429. This duct is* a membranous canal, slender, strong, more or less tortuous, subject to great varieties in its course and division,† destitute of muscular fibre and nerves, and possessing here and there valves. At about the lowest cervical vertebra, after passing the subclavian vein, it turns back again,‡ and is inserted into it, being furnished with a peculiar valve at the point of insertion.

430. The motion of the chyle throughout its course is to be ascribed to the contractility of its containing vessels, to their valves, and the vis-a-tergo.

431. The use of the valve placed at the opening of the thoracic duct, is probably not so much to prevent the influx of blood, as to modify the entrance of the chyle into the vein,—to cause it to enter by drops.

By this contrivance, such a portion of fresh chyle cannot have access to the blood as would stimulate the cavities of the heart too violently and be imperfectly and difficultly assimilated; for fresh chyle consists of very heterogeneous elements, brought not only from the primæ viæ by the lacteals, but from every part of the body by the lymphatics.

432. These *lymphatics,*§ which constitute the third

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* See Haller, *Observationes de ductu thoracico in theatro Gottingensi factæ.* Gotting. 1741. 4to.

B. S. Albinus, *Tabula vasis chyliferi.* LB. 1757. large folio; Mascagni, tab. xix.

† v. J. C. Bohl, *Viæ lacteæ. c. h. historia naturalis.* Regiom. 1741. 4to.

Sömmering, *Commentat. Soc. Scient. Gottingens.* T. xiii. p. 111.

‡ v. Haller, *Opera Minora.* Vol. i. tab. xii.

§ Consult, among others already and hereafter quoted, J. F. Meckel, *De*

vasis

part of the absorbent system, and resemble the lacteals in structure and function, are much more, and perhaps, indeed, universally, diffused.* They arise principally from the mucous web, which we therefore called the grand bond of connection between the sanguiferous and absorbing system; (27) but in great numbers likewise from the external common integuments, from the fauces and œsophagus, (330), the pleura and peritonæum, and from the thoracic and abdominal viscera.†

433. Their origin is similar to that of the lacteals in the intestines, so that the radicle of each lymphatic absorbs the fluid from the neighbouring cellular membrane, as from its territory, and propels it onwards.

434. The lymphatics have double valves, set more or less thickly in different parts; they all enter conglobate glands; those which are contiguous to each other anastomose here and there; and those found on the surface of certain viscera, as the lungs, liver, &c. form a most beautiful network.

435. Besides other aids to their functions, evident from what has already been said, no inconsiderable assistance is derived from the combination of great strength with thinness in their coats, by which they are enabled to support a heavy column of quicksilver. In the limbs, especially, the motion of the muscles pressing them on every side, is highly useful in increasing their power.

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vasis lymphaticis glandulisque conglobatis. Berol. 1757. 4to. And the celebrated Al. Monro, filius, *De venis lymphaticis valvulosis.* ib. same year. 8vo.

* W. Hunter, *Medical Commentaries.* P. i. p. 5 sq.

† Mascagni. Tab. i. ii. iii.

T. Gottl. Haase, *De vasis cutis et intestinorum absorbentibus, &c.* Lips. 1786. fol. tab. i.

436. But their principal action, by which they take up fluids more or less rapidly, eagerly absorbing some and absolutely rejecting others,* depends upon the peculiar modification of their vitality, and is ascribed by the very acute Brugmans to a certain *vita propria*. (42) †

437. The far greater part of these lymphatics terminate in the thoracic duct; except, however, those of the right arm, the right side of the neck, the right lung, and the right portion of the diaphragm and liver, which terminate in the subclavian vein of the same side.

438. From the universal existence of the lymphatics, and especially from the great numbers on the surface, capable of absorbing fluids from without, the heterogeneous nature of the lymph must be obvious; and this is further proved by accurately examining it in different parts of a subject; v. c. that contained in the hepatic or splenic lymphatics is perfectly different from that in the uterine.

439. We will enumerate the principal fluids which are continually absorbed during health, to say nothing of many different kinds of substances taken up during disease. There is, besides the chyle separated from the fæces in the small intestines, the halitus of the cavities properly so called, especially that of the fauces and of all the mucous tela, the fat, the more watery

* On this remarkable difference consult T. Fr. Lucr. Albrecht, *Commentatio* (honoured with the Royal Prize) *in qua proponitur recensus eorum alimentor. et medicaminum, quibus, sive tubo alimentario sint ingesta, sive communibus corporis integumentis applicata, ingressus in systema vasor. sanguifer. aut concessus a natura, aut negatus sit.* Gotting. 1806. 4to.

† Conr. Ger. Ontydt (Præsidente Seb. Just. Brugmans), *De Causa absorptionis per vasa lymphatica.* Lugd. Bat. 1795. 8vo. p. 45.

part of those secreted fluids which are retained for some time in their ducts, v. c. of the milk, semen, bile, &c. and not a small portion of the stillatitious fluids that are applied to the common integuments.*

440. The solids, after performing their purpose in the economy, insensibly melt away and are absorbed, as is proved by the absorption of the greater part of the thymus gland during infancy, of the roots of the first teeth, and of the alveoli after the second teeth have fallen out. The constant change of the whole osseous system, arising from the insensible renovation of the bony matter, of which we have treated elsewhere professedly,† may also be adduced.

441. It is therefore evident, since so great a variety of matter is absorbed, and at the same time nothing crude or improper allowed to enter the blood, that there is a necessity for some peculiar medium to previously subact and assimilate the various substances.

442. It appears to be the chief office of the *conglobate glands*, which constitute the last part of the absorbent system, to prevent the ill effects, upon the heart, of the improper admixture of crude fluid ‡ with

* Consult among others, Valer. Lud. Brera, *Anatripsologia ;* fourth edition. Par. 1799. 2 vols. 8vo. A. J. Chrestien, *De la méthode iatroliptice*, Montpell. 1803. 8vo.

† Decade 1. of my collection of the crania of different nations. p. 27.

‡ If we consider the winding course which nature has provided for the purpose of changing and assimilating the absorbed fluids before their admixture with the blood; and, on the other hand, the dreadful symptoms, such as palpitation, convulsions, &c. which ensue upon the *artificial infusion* of a minute portion of any mild fluid into the blood, we shall be thoroughly convinced that no absorption of heterogeneous fluid takes place by the *veins, excepting that of the blood itself* (v. c. in the erection of some parts, in the placenta,

the blood, by assimilating the various fluids, particularly those absorbed by the skin, more and more to an animal nature, by retarding their motion, and perhaps also by superadding to them some fresh secreted fluid. (E)

443. These glands that are dispersed generally through the body, and aggregated here and there, as in the groin and axillæ, are perfectly similar to those found in the mesentery, consisting, like them, in a great measure, of convoluted absorbent vessels, supplied with an immense number of blood vessels, and liable to the same diseases.*

NOTES.

(A) Dr. W. Hunter, Mr. Cruikshanks, and others, saw the *villi* of the intestines perfectly white in a person who had died soon after eating, and twenty or thirty orifices, in a single villus, forming tubes that ran to its base and united into one trunk.†

(B) If a gland is well injected, the numerous ramifications of the absorbents prevent cells from appearing, but if injected less minutely, cells are very evident, and distinct from the convolutions and ramifications of vessels. "If an absorbent gland of a horse is filled with quicksilver and dried, and then carefully slit open, the cells will be seen of a large size, and bristles may with ease be passed through the openings by which they communicate."‡

&c.), and that those absorptions which Haller endeavours to prove to be accomplished by the veins, do really take place by means of the lymphatic system. *De c. h. Funct.* Vol. i. p. 281 sq.

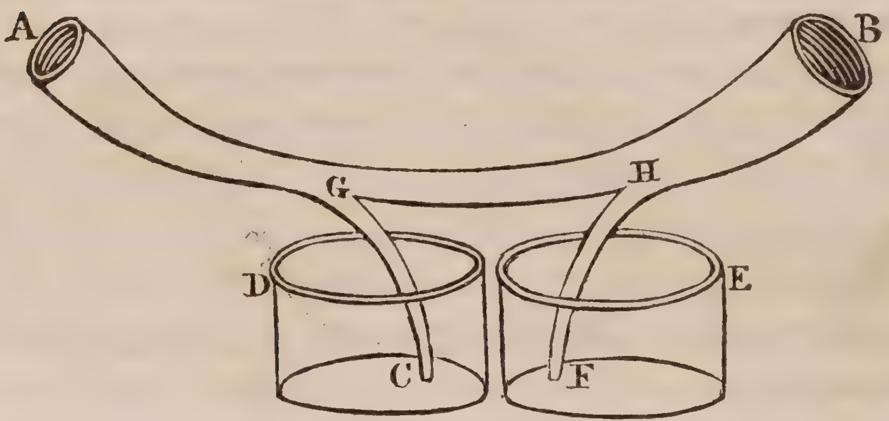
* Nuck, *Adenographia Curiosa.* LB. 1696. 8vo.

† Wilson, *Lectures on the Blood*, &c. 198.

‡ Wilson, l. c. page 203. Mr. Abernethy has described them in the whale as well as in the horse. *Phil. Trans.* 1796.

It is imagined that the vasa inferentia pour their contents into these cells, and that the efferentia afterwards absorb it from them.

(C) Lieberkühn's tube was of this shape :—



Water propelled into A, passed out at B and C, but not at F. Even if F was immersed in a coloured fluid, this ascended to H, and passed out at B with the water.

(D) M. Majendie * contends that the lacteals absorb nothing but chyle, asserting that neither he nor Hallé have ever seen the chyle in these vessels tinged by coloured ingesta, and that neither he nor the veterinary surgeon Flandrin ever found any thing but chyle enter the lacteals. Lister's experiment has succeeded with Blumenbach, Hunter, and numerous others, and Mr. Hunter in the presence of several persons poured milk into the intestines of a dog, and they all observed it quickly to fill the lacteals. M. Majendie must pardon an Englishman for inclining to the *positive* result of Hunter's experiment, notwithstanding it failed in his hands. Among other insignificant objections, he urges that Mr. Hunter should have first noticed whether the vessels contained chyle, whereas it is expressly mentioned that, before the milk was poured into the intestine, the lacteals were seen distended by a nearly colourless and pellucid fluid.†

He also revives the old opinion—that the lymphatics arise from

* *Précis Elémentaire*, &c. T. ii. p. 178 sq.

† *Medical Commentaries.*

arteries only, and are destined to convey lymph from them.* Mr. Hunter, after pouring water coloured by indigo into the peritoneum of an animal, saw the lymphatics filled with a blue fluid. In the hands of M. M. Majendie, Flandrin, and Dupuytren, this experiment likewise has failed. He does, however, allow that, in a woman who died with a collection of pus in the thigh, the surrounding lymphatics were distended with pus to the size of a crow's quill;—a pretty decisive fact. The absorbents of fish have no valves except at their termination in the red veins, and may therefore be injected from the principal trunks: the injection passes out of the mouths of the absorbents in numerous streams, and especially on the back, if the skate is employed;—another decisive fact.

The ancient doctrine of veins being the organs of absorption forms a leading feature in his physiology.† Mr. Hunter deposited various fluids in the intestines, but, although he found manifest traces of them in the absorbents, he could discover none in the mesenteric veins. M. Majendie relates two experiments in which a decoction of nux vomica, introduced into the alimentary canal, produced its usual effects, though the thoracic duct was tied and ascertained to be single. But, as the poison may operate through the nervous system, these experiments prove nothing. Even the same objection applies to a similar experiment in which, instead of the thoracic duct being tied, the portion of intestine containing the solution was totally separated from the body, except in one artery and one vein. Indeed the poison might be conveyed by absorbents in the coats of the vessels. Another experiment appears at first sight unobjectionable, because not only was every part of a limb separated from the body except the large artery and vein, but even these were cut asunder, quills having been previously introduced into them and fixed to carry on the circulation, and yet some upas plunged into the paw of the animal exerted its peculiar influence, which besides was suspended and permitted at pleasure by com-

* l. c. p. 185 sq. † l. c. p. 238.

pressing or liberating the vein under the finger and thumb. But here again an objection presents itself, which in fact applies likewise to all the preceding experiments:—not only has Mr. Bracy Clarke discovered communications in the horse between the lymphatic system and lumbar veins,* but M. Majendie allows that the absorbents communicate with arteries, and may frequently be injected from them: the poison might consequently on his own admission be imagined to be taken up by lymphatics, carried into small blood-vessels, and conveyed with the blood through the vein to the body. Indeed, as the poison was placed in a wound, it might contaminate the blood without being absorbed.—Against the result of an experiment in which, after a solution of prussiate of potass was swallowed, the salt was discoverable in the urine and not in the lymph, M. Majendie himself supplies an objection when treating of the urine. For he states that a minute portion of this substance may be readily detected in the urine, while the quantity in the blood must be large to be discoverable. As the contents of the thoracic duct so nearly resemble blood, he should have ascertained whether it is not difficult to detect in them also a portion of the prussiate which would be easily manifest in the urine. A similar experiment with a decoction of rhubarb, lies under the same difficulty.

In starting all these doubts, I am only desirous of showing that M. Majendie's experiments are not so unobjectionable as he believes, and readily grant that Mr. Hunter's experiments deserve repetition and the whole subject farther investigation. I am not prepared to deny that veins absorb, or, what comes to nearly the same thing, that there are lymphatics which do not form trunks but convey their contents to small blood-vessels; and I have nothing to suggest against the following facts.

"Three ounces of diluted alcohol were given to a dog; in a quarter of an hour the blood of the animal had a decided smell of alcohol; the lymph (of the thoracic duct) had none."

"In the horse, the usual contents of both the large and small

* Rees's *Cyclopædia:* Anatomy, Veterinary.

intestines are mixed with a large quantity* of fluid that gradually decreases towards the rectum and is therefore absorbed as it passes along the canal. Now, Flandrin, having collected the contents of the lacteals, did not find them smell like this intestinal fluid, whereas the venous blood of the small intestines had a taste distinctly herbaceous; that of the cæcum a sharp taste and a slightly urinous smell; and that of the colon the same qualities in a more marked degree. The blood of other parts presented nothing analogous."

"Half a pound of assa fœtida dissolved in the same quantity of honey was given to a horse, which was afterwards fed as usual and killed in sixteen hours. The smell of assa fœtida was perceptible in the veins of the stomach, small intestines, and cæcum; but not in the arterial blood, nor in the lymph."†

The last quotation presents as positive results in regard to veins, as Mr. Hunter's experiments in regard to lacteals and lymphatics.

(E) Although some albumen is discovered actually in the duodenum, and some fibrine in the first lacteals, the chyle is found to contain more and more of these substances in proportion to its progress towards the left subclavian vein. The chyle contains a certain fatty matter, which is considered as *incipient albumen*, and, in proportion as this decreases, does the quantity of fibrine and albumen increase.‡

* l. c. page 182-3. † l. c. page 240.

‡ Dr. Prout, Thomson's *Annals of Philosophy*. 1819.

SECT. XXX.

OF SANGUIFICATION.

444. There is scarcely occasion to remark that we employ the term Sanguification to denote the assimilation of the chyle to the blood, and the constant reparation, by means of the *former*, of the constant loss sustained by the *latter*.

445. The division of all our fluids into three classes—(45)—*crude*, *sanguineous*, and *secreted*, turns upon this;—that the middle class contains the stream of the vital fluid itself, from which the numerous secreted fluids are perpetually withdrawn, and to which, on the other hand, there is a constant afflux of chyle and lymph from the absorbent system.

446. But since the blood is a peculiar fluid, *sui generis*, without its fellow in nature, various assistances and media are evidently requisite to subact and assimilate the heterogeneous and foreign fluids which pass to it from the thoracic duct.

447. This is, in the first place, especially in the mesenteric and other conglobate glands, favoured by those windings, mentioned formerly, of the lacteals and lymphatics, which are, at the same time, gradually more impregnated, as it were, with an animal nature.

448. We must also take into consideration, that a great part of the lymph which enters the left subclavian after its admixture with the intestinal chyle in the thoracic duct, has been derived from the substance of

the viscera and other soft parts, formerly secreted from the blood, and, therefore, already imbued with an animal nature, and easily, without doubt, again miscible with the mass of blood, to which it does but return.

449. Something is contributed by the slow and almost stillatitious manner in which the chyle drops into the blood through the last valve of the thoracic duct, these very minute portions becoming thus the more intimately combined with the blood.

450. The heart, too, by means of the remarkable papillary muscles of the ventricles, agitates and mingles the blood just impregnated with fresh chyle.

451. The great importance of the lungs which receive the blood immediately after its addition of fresh chyle, and also of respiration, in the business of assimilation,* will be evident on considering the extraordinary vascularity of those organs (14) and their constant and regular motion.

452. The remaining part of sanguification is accomplished by the general circulation and the powers which aid it, particularly by muscular motion, &c.

453. Although so many means are provided for the combination of the chyle with the blood, and although the constituents of the chyle somewhat resemble those of this fluid; nevertheless, it is commonly asserted that many hours are required for the complete change of the colour of the chyle and for its assimilation. Besides other arguments in favour of this assertion, the pathological fact is urged, that chyle is frequently seen

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* Especially, according to the opinion of Cuvier, in the conversion of the chyle into the lymphatic or fibrous part of the blood. *Lécons d' Anatomie Comparée.* T. i. p. 91. T. iv. p. 304. Thomson, *System of Chemistry*. Vol. iv. p. 497. Bostock's work, recommended above, in the chapter *on Respiration.*

in blood drawn many hours after digestion. I myself have witnessed this appearance in cases where the blood too evidently bore an inflammatory disposition, to use a common phrase; but I am persuaded that no inference can be hence deduced in regard to the healthy state, which alone is the object of physiology.

NOTE.

The fluid collected from the thoracic duct separates like the blood into a solid and a serous portion. If formed from vegetable food, it is nearly transparent, may be kept weeks or even months without putrefying, and affords a faintly pink coagulum. If from animal food, it is white and opake, begins to putrefy in a few days, affords an opake coagulum which acquires a more marked pink hue by the influence of the atmosphere, and throws upon its surface a white creamy substance. The former gives three times as much carbon as the latter; but the latter being so much richer gives much more carbonate of ammonia and heavy fixed oil, when subjected to the destructive distillation.* *Chyle* collected from lacteals is whiter, coagulates less perfectly, and does not acquire a red colour by exposure to the air,† so that sanguification proceeds gradually, as the chyle passes towards the left subclavian vein,—a circumstance already stated in the last section, Note (E). The pink colour, acquired by the coagulum of chyle when exposed to the atmosphere, shews the use of the lungs in sanguification.

Dr. Marcet has reason to believe that the appearance of creamy matter floating in the serum of blood occurs most frequently

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* Dr. Marcet, *Med. Chir. Trans.* Vol. vi.

† *Annales de Chimie.* T. lxxx. and lxxxi.

when the food is chiefly animal, and when therefore rich chyle is poured into the blood faster than it can be assimilated.

I lately saw a young married woman whose urine contained very large coagula of chyle. She always dined at noon. In the evening the coagula were white; in the morning pale with pink streaks. After fasting twenty-four hours at my request, the coagula still appeared in the urine, extremely pale, and shewing more pink streaks. She had been some months in this way, was in very fair health, and had a great appetite, and perhaps some other general symptoms of diabetes; but there was no sugar in the urine. Notwithstanding the fluid discharged seemed to present as much coagulum as urine, the quantity of chyle proved on drying to be very minute, and from its looseness to have been extremely distended by the urine. As this was a state of disease, I draw no inference from the case respecting the time necessary for the change of chyle to blood. She would not allow me to take any blood from the arm for observation.

Lymph is of a straw-colour and coagulates spontaneously.

SECT. XXXI.

OF NUTRITION.

454. Besides the function of the blood formerly investigated,—of distributing oxygen through the system and removing carbon, its principal use is to afford nourishment to the body in general, and to the secreting organs the peculiar fluids which they possess the power of deriving from it. Nutrition shall be first examined.

455. *Nutrition* is the grandest gift of nature, and the common and highest prerogative of the animal and vegetable kingdoms, by which these, beyond measure, surpass, even at first sight, all human machines and automatons. Upon these no artist can bestow the faculty, not to say of increasing and of coming to perfection, but even of existing independently and repairing the incessant losses incurred from friction.*

456. By the nutritive faculty of the body, its greatest and most admirable functions are performed; by it we grow from the first of our formation and arrive at manhood; and by it are remedied the destruction and consumption which incessantly occur in our system during life.†

* "Nutrition, in fact, appears to be a continued generation," according to the old observation of the very ingenious Ent. See his work, already (290. n.) recommended.

† Th. Young, *De corporis humani viribus conservatricibus.* Gotting. 1796. 8vo.

Fl. J. Van Maanen, *De natura humana sui ipsius conservatrice ac medicatrice.* Harderv. 1801. 8vo.

457. Respecting the nature of this consumption, there has been much dispute whether it affects the solids,* or, whether, according to some very acute writers,† these, when once formed and perfected, remain invariably entire.

458. There can be no doubt that some of the similar solids, v. c. the epidermis and nails, are gradually destroyed and renewed; and the same is proved respecting even the bones, by the well known experiment of dyeing them with madder root, (A) and by the frequently surprising attenuation of the flat bones, especially of the skull, from defective nutrition in old age.‡

459. If I am not mistaken, those solid parts undergo this successive change, which possess the *reproductive power*—an extraordinary faculty, by which not only the natural loss of particles, but even the accidental removal of considerable parts, from external injuries, is repaired and perfectly supplied, as the bones § and a few other parts sufficiently demonstrate.

460. On the other hand, I have been led by many experiments to the conclusion—that this genuine *re-*

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* See the celebrated V. J. Bernouilli's Diss. *de nutrit.* Groning. 1669. 4to. He estimates the continual, though insensible, loss and reparation of the solids so high, that the whole body may be said to be destroyed and renewed every three years.

† See J. Chr. Kemme, *Beurtheilung eines Beweises vor die Immaterialität der seele aus der Medicin.* Halle. 1776. 8vo.

And his, *Zweifel und Erinnerungen wider die Lehre der Aerzte von der Ernährung der festen Theile.* Ibid. 1778. 8vo.

‡ Respecting this mutability of the bones, I have spoken at length in my osteological work. ed. 2. p. 26, and elsewhere.

§ Consult among others G. L. Koeler, *Experimenta circa regenerationem ossium.* Gotting. 1786. 8vo.

Alex. Herm. Macdonald, *De necrosi et callo.* Edinb. 1799. 8vo.

productive power appears completely bestowed upon no similar parts *which possess any other vital power* BESIDES CONTRACTILITY, i.e. *irritability, sensibility,* or a *vita propria.** (B)

461. In those parts, therefore, whose vital powers are of an higher order, the parenchyma, constituting their base, appears permanent and is liable to this change only,—that the interstices of the fibres and parenchyma, while nutrition is vigorous, are constantly full of nutrient animal gelatine; but when nutrition languishes, are deprived of the gelatine, collapse, and consequently become thin.

462. For as the plastic lymph, the importance of which has been frequently mentioned, is readily converted into cellular membrane, so it appears to constitute the principal material of the body, and, as it were, the animal gluten, which is nourished by its means.

463. During the growth of the body, peculiar powers are exerted, by which the lymph deposited in the cellular membrane from the blood-vessels is properly distributed and intimately assimilated to the substance of each organ, &c. This is referrible both to the laws of affinity, by which particles attract, and, as it were, ap-

* That the corium is not really reproduced, is probable, not only from its perpetual *cicatrices* (for some contend that the *matter* of those does not continue, but their *form* only, which is preserved by a perpetual apposition of fresh particles in the room of the decayed and absorbed), but much more by the lines and figures which are made upon the skin by the singular art of pricking it with a needle, (a process denominated in the barbarous language of the Otaheiteans *tatooing*) and imparting to the corium a blue or red colour, as permanent as the cicatriculæ, by means of charcoal powder, ashes, soot, the juices of plants, or galls; on the other hand, the red hue imparted to the bones, by means of madder, quickly disappears, as these parts undergo a continual renovation.

propriate others which are similar and related to themselves; and to the nisus formativus, which we shall enlarge upon hereafter, and to which the proper application of shapeless elementary matter and its modification to particular forms, must be ascribed.

464. The union of both these powers, we conceive, must be the source of the nutrition of such similar parts as are not supplied with blood, but are, nevertheless, at first generated by a most powerful and infallible nisus, grow, are nourished, and, if destroyed by accident, are very easily reproduced;* such are the nails, hairs, &c.

465. As this appears to be the true account of nutrition in general, so, on the other hand, it evidently has great varieties of degree and kind, especially where, from the more or less lax apposition of the nutritious matter, the structure of the similar parts is more or less dense, and the specific weight of the whole body more or less considerable.† In this respect, not only individuals, but whole nations, differ from each other. The Yakuts and Burats, who are remarkable for the lightness of their bodies, are a sufficient example of this.

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* *Zwo Abhandlungen über die Nutritionskraft welche von der Acad. der Wiss. in St. Petersburg den Preiss getheilt erhalten haben.* Petersburg. 1789. 4to.

De Grimaud, *Mém. sur la nutrition qui a obtenu l'accessit.* Ib. same year. 4to.

Steph. J. P. Housset, on the same subject (in the same school) in his *Mémoires physiologiques et d'hist. naturelle.* Auxerre. 1787. 8vo. T. i. page 98.

† J. Robertson, *On the specific gravity of living men. Philos. Trans.* Vol. L. P. i. page 30 sq.

NOTES.

(A) The redness imparted to the bones by feeding animals with madder, does not prove that the matter of the bones is constantly changing; because the opinion that the madder unites with the phosphate of lime in the blood and thus reddens all the bony matter subsequently deposited, is erroneous. Mr. Gibson proved, by numerous experiments, that the serum has a stronger affinity than the phosphate of lime, for madder. The serum being charged with madder, the phosphate of lime of the bones, already formed, seizes the superabundant madder and becomes red. If the madder is no longer given to the animal, as it is continually passing off with the excretions, the stronger attraction of the serum draws it from the bones, and they re-acquire their whiteness.*

(B) The constant renewal of the epidermis is demonstrated by wearing black silk stockings next the skin. That the hair and nails not only grow perpetually, but are even reproduced, is certain from the great quantity of the former which falls off the head *whole* if worn long, while a good head of hair still continues; and from the renewal of the latter, after the loss of a good part of a finger. I lately attended a middle-aged woman, in St. Thomas's Hospital, who had lost nearly the whole of the first phalanx of a finger, and yet the stump was tipped by a nail, though certainly a clumsy one. An instance of a nail at the end of the stump, after the complete removal of the first phalanx, may be seen in the London Medical and Physical Journal.† Tulpius declares he has seen examples after the loss of both the first and second phalanges (in secundo et tertio articulo).‡ The glans penis (in truth a mere continuation of the corpus spongiosum urethræ) was entirely renewed in a case described in the Edinburgh Medical and Physical Essays.§ Nothing more can,

* *Manchester Memoirs.* vol. i.

† 1817.

‡ *Observationes Medicæ.* iv. 56.

§ Vol. v.

I apprehend, be said, respecting the entire restoration of organs in the human body. Portions of cutis, bone, membrane, blood-vessels, absorbents, and nerves are replaced. That portions of large nerves, fully capable of all the functions of the destroyed pieces, are reproduced, is now a matter of certainty. Minute blood-vessels and absorbents are of course allowed on all hands to be produced in the cure of all solutions of continuity;* but Dr. Parry, senior, has proved most satisfactorily that in the ram, at least, when a blood-vessel which proceeds some way without giving off a branch is obstructed, new branches sprout forth and establish a communication on each side of the obstruction.† The continuance of circulation was previously attributed to the enlargement of the small anastomosing vessels. Muscle is supplied by tendinous matter.

Brutes far surpass man in both the ordinary renewal of the integuments and appendages, and in the extraordinary restoration of destroyed organs. The horse periodically sheds

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* Mr. Bauer has observed vegetable tubes to be constructed by the extrication of carbonic acid gas into a slimy matter prepared for nutrition. Some such opinion was held by Borelli, Tabor, and Hales. He has reason to explain the formation of blood-vessels in coagulated fibrine and pus in an analogous manner, but his experiments have not yet advanced far enough for me to dwell upon them. *Phil. Trans.* 1818 and 1819.

Not only divided parts reunite, but even portions completely separated and cold, and parts of different bodies. A soldier's arm was struck off at the battle of Arlon, with the exception of a piece of skin and the subjacent vessels and nerves, and yet the muscles, bones, &c. completely reunited in about eight months. *Dictionnaire des Sciences Médicales.* T. xii.

Garengeot saw a nose unite after being bitten off, trampled upon, and allowed to lie in the dirt till it was cold. *Traité des Operations de Chirurgerie.* T. iii. Dr. Balfour saw a similar occurrence in the instance of a finger. *Edinburgh Med. and Surgical Journal.* 1815.

Transplantation, for instance, of the cock's testes to the hen's abdomen as well as of the spur to the head, is very common, and was mentioned a century and a half ago by Bartholin. *Epist. Cent.* 174.

† See Ch. VII. (F.)

its hair, the bird its feathers,* the stag its horns, the serpent its cuticle, the lobster its shell and the teeth that are in its stomach.† The fall of the leaves of trees is an analogous circumstance. The extraordinary reproductive power of some brutes is almost incredible. A lobster can reproduce a claw, a water-newt an extremity: Blumenbach actually observed the reproduction of the whole head with its four horns in a snail, and the complete eye,—cornea, iris, crystalline lens, &c. in a water-newt.‡

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* Feathers which are not cast off have been lately discovered to receive an increase of colour. *Linnæan Transactions.* 1818.

† This corroborates the propriety of the view taken by Dr. Prout in an unpublished paper written many years ago, in which he contends that the teeth are to be arranged with the integuments. Some naturalist has lately published a similar opinion.

‡ *Göttingen literary notices.* 1787.

SECT. XXXII.

OF THE SECRETIONS IN GENERAL.

466. BESIDES the nutritious fluids, others of various descriptions are produced from the blood by means of *secretion,* which Haller, no less than his predecessors, with truth and regret declared to be among the most obscure parts of physiology.*

467. The secreted fluids differ, on the one hand, so considerably among themselves, and, on the other, have so many points of resemblance, that their classification cannot but be extremely arbitrary. If we arrange them according to the degree of difference between them and the blood from which they are formed, they will stand in the following order.—

First, the *milk,* which may be in some degree considered as chyle reproduced, and appears formed by the most simple process from the blood newly supplied with chyle.

Next, the *aqueous* fluids, as they are commonly denominated from their limpid tenuity, although the greater part differ importantly from water in the nature of their constituents, and especially in the proportion of albumen: such are the humours of the eye, the tears, in all probability the vapour contained in the cellular interstices and the cavities of the abdomen and thorax;

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* v. Fouquet on Secretion, in the Encyclopedical Dictionary of Paris. T. xiv. Fr. L. Kreysig, *De secretionibus.* Spec. i. ii. Lips. 1794 sq. 4to.

nearly similar, also, is the fluid of the pericardium and of the ventricles of the brain.

The liquor amnii of pregnancy, and the *urine*, remarkable for the peculiar nature and mixture of its proper constituents, are generally enumerated among these.

The *salivary fluids*, concerned in mastication, digestion, and chylification, appear more elaborated.

Next the *mucous*, which line the cavities of most of the organs performing the natural and genital functions, and likewise the tract of the nostrils, larynx, and trachea.

The mucus within the eye, and under the epidermis, is nearly similar.

In the same class may be included the cerumen of the ears, the unguent of the Meibomian glands and of the joints, and, perhaps, the nameless fluid poured forth into the vagina during the venereal œstrum.

The *adipose* are, besides the common fat, the medulla of the bones and grease of the skin.

Related to these are the secretion of the corona glandis under the preputium, and of the external female genitals.

The truly *serous*, or albuminous, are the fluid of the ovarian vesicles of De Graaf, and the liquor of the prostate.

The *semen virile* and the *bile* are each sui generis. (A)

468. It is obvious that so great a variety of secreted fluids cannot be secreted from the mass of blood in the same way, nor by similar organs. They differ extremely from each other in the simplicity or complexity of their preparation.

469. The most simple mode of secretion is diape-

desis, or transudation; which is the case with the fat and the bony fluid.*

470. Secretion by *glands*† is more complicated. Such is considered the secretion even by follicles and cryptæ, which are found, v. c. in some parts of the corium, the fauces, and aspera arteria, and denominated the *most simple* glands.

Properly speaking, the *conglomerate* (as they are called to distinguish them from the lymphatic conglobate) are the only true secreting organs; such as the salivary and lachrymal glands, the pancreas and breasts. They are provided with an excretory duct coming immediately from the large lobes, which are composed of others, smaller, and so intricate in their structure as to have been the source of warm disputes in the schools of medicine. Malpighi‡ considered the

* Physiologists have given different explanations of this mode of secretion. Some assert that every fluid is formed by passing merely through inorganic pores from the blood: others altogether deny the existence of these pores. I think much of this is a verbal dispute. Because, on the one hand, I cannot imagine how *inorganic* pores can be supposed to exist in an *organised* body, for we are not speaking of the common interstices of matter, in physics denominated pores; and I am persuaded that every opening in organised bodies is of an organic nature and possesses vital powers exactly correspondent. On the other hand, these openings or pores, which indisputably exist in the coats of vessels, I think but little different in function at least from the cylindrical ducts through which fluids are said to percolate in conglomerate glands and secreting viscera: for this percolation depends less on the *form* of the organ than on its *vital powers.* (B)

Consult, among others, Schreger, *Fragmenta.* p. 37; already recommended.

P. Lupi, *Nova per poros inorganicos secretionum theoria refutata, &c.* Romæ. 1793. ii. Vol. 8vo.

Kreysig, *Specimen secundum;* formerly mentioned.

† Sam. Hendy, *On Glandular Secretion.* Lond. 1775. 8vo.

‡ In works repeatedly quoted, and also in his *Diss. de glandulis conglobatis.* Lond. 1689. 4to.

But

miliary globules, which are easily discoverable in most glands, as acini internally excavated. Ruysch, on the contrary, contended that these supposed hollow acini were nothing more than glomerules of blood vessels,—an opinion far more consistent with microscopical observation and the effects of minute injection.

471. The strúcture of some secreting organs, especially of the liver and kidneys, the latter of which strikingly exhibit the glomerules of Ruysch or the acini of Malpighi, are not, excepting in their peculiar parenchyma, very dissimilar from this structure, and indeed throw considerable light upon the question. On the outer part of these, small twigs arise from the sides of the capillary arteries and run into vascular glomerules, hanging like granules as from stalks: from these arterial glomerules spring both very minute colourless secreting vessels whose origin from the extremities of arteries was formerly alluded to (92), and the radicles of veins into which the arteries are continued, and which convey back into the venous trunks the remaining blood deprived of the secreted fluid.*

472. The organisation of some other secreting parts is evidently peculiar, v. c. of the testes, which are composed of very long and numerous vessels, closely compacted, &c.

473. That the different nature of the secreted fluids depends not so much on the size and external form of the secreting organs as upon their interior structure and corresponding vital powers, is rendered probable by

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But consult especially his *Opera Posthuma*. ib. 1697. fol.; and published likewise elsewhere.

* Al. Schumlansky, *De structura renum*. Argent. 1782. 4to. tab. ii.

the example of many of our fluids, which, although secreted by organs at first sight very different from each other, have considerable resemblance to each other in nature; v. c. the saliva and gastric juice. And comparative anatomy teaches us, that the same fluids are formed by organs very different in external appearance, in different animals.* (C)

474. We shall now investigate the causes why particular fluids are found in particular organs,—the most difficult part of the doctrine of secretion, and still open to many doubts.

475. There can be no question that the absolute cause of the variety of secretions is referrible to the intimate nature of the secreting organ. This depends, in the conglomerate glands and secreting viscera especially, both upon the direction and distribution of the secreting blood-vessels, and upon the peculiar *parenchyma* of each secreting organ, in some instances distinguishable at first sight from the substance of every other part. (20)

476. It is likewise probable, and indisputable arguments in favour of the opinion have been continually afforded in the course of this work, that secreting organs have not only a peculiar parenchyma, but a *vita propria*—a peculiar species of vitality distinct from the common vital powers of contractility, irritability, and sensibility. (D)

477. The absorbent system seems of much import-

* Compare, for instance, the form of the kidneys in mammalia with the true conglomerate glands which supply their place in birds; or the pancreas of warm-blooded animals with the pyloric appendices which, although varying in appearance in different fish, secrete a fluid very similar to the pancreatic.

ance in the business of secretion. In every secreting organ, it absorbs, for the purpose of transmission to the blood, a fluid which is, as it were, contaminated by the secretion of the part: v. c. a bilious fluid in the liver; a spermatic in the testes. A constant circle would, therefore, appear to exist in the secretory system, so that the elements of the secretions are incessantly carried to the blood from the secreting organs, and, when they return to the organs, are the more easily attracted by a species of affinity, and draw with them those parts of the blood whose nature is related to their own.

478. The blood from which some secretions are produced, is endowed with peculiar qualities. The bile, for example, is derived from blood which contains an abundance of carbonaceous element.

479. We omit other assistances afforded to certain secretions; v. c. congestion and derivation, so striking in the secretion of milk, &c.

480. There is this difference among the various fluids secreted by the organs and powers now described,—that some pass to the place of their destination immediately, while others are deposited in receptacles, and detained there for a length of time, becoming more perfect before their excretion. The milk in its ducts, the urine, bile, and semen in their respective bladders, and in some degree the serum of the vesicles of De Graaf, are examples of this.

NOTES.

(A) "There are two classes of secreted fluids, viz. the *secretions*, properly so called, or the fluids intended to fulfil some ulterior purpose in the animal economy, and the *excretions*, which are directly discharged from the body. The fluids of the former class are all alkaline, and of the latter all acid. The excretions are the urine, the perspired fluid, and the milk. All the other fluids appear to belong to the former class.

"The alkaline secreted fluids may be divided into two very distinct species. The former of these contains the same quantity of water as the blood, so that the change induced by the nervous influence, seems to be confined to that of altering the chemical form of the albuminous materials,* without affecting their relative proportion to the water and other substances dissolved in the blood. The bile, spermatic fluid, &c. are of this kind. The latter species consists of fluids, in which the influence of the nervous system has separated a large portion of the albuminous matter, and left the remaining liquid proportionally watery. The saliva, the humours of the eye, and the effused serum of membranes, are of this species, and in these the quantity of salts, and in general also of alkali, is the same as in the blood.

"The influence of the chemical agent of secretion is, therefore, chiefly spent upon the albuminous materials of the blood, which seems to be the source of every substance that peculiarly characterises each secretion, each of which is *sui generis,* and is its principal constituent. All the other parts of the secretion seem to be rather accidental, and to be found there only because they were contained in the blood out of which the secretion was formed. Therefore, in examining the secreted fluids, the chief attention should be paid to the peculiar matter of the fluid, which

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* This appellation Berzelius gives to the fibrine, albumen, and colouring matter of the blood.

varies in all. This matter sometimes retains some of the properties of albumen, at other times, none; and hence an accurate analysis, shewing the quantity and nature of this peculiar matter, is above all to be desired.

"If the several secretions be supposed to be deprived of their peculiar matter and the remainders analysed, the same residue would be found from them all, which also would be identical with the fluid separated from the serum after its coagulation. Thus we should find, first, a portion soluble in alcohol, consisting of the muriates of potash and soda, lactate of soda, and of an extractive animal substance, precipitable by tannin; and secondly, of a portion soluble only in water, containing soda (which acquires carbonic acid by evaporation, and is separable by acetic acid and alcohol) and another animal substance, not extract, precipitable from its solution in cold water, both by tannin and muriate of mercury. Sometimes a vestige of phosphate of soda will also be detected.

"The excretions are of a more compound nature. They all contain a free acid, which is termed lactic, and in the urine this is mixed with the uric acid. Urine seems to contain only a single peculiar characteristic matter; but milk has as many as three, viz. butter, curd, and sugar of milk, which, however, seem to be produced by different organs that mingle their fluids in the same receptacle. The perspired fluid appears to have no peculiar matter, but to be a very watery liquid, with hardly a vestige of the albumen of the blood, and, in short, is the same as the other excretory fluids would be when deprived of their peculiar matter. If we suppose this matter taken away from those excretions which possess it, the remaining fluid will be found to have properties very different from the fluid part of the secretions, when equally freed from their peculiar matter. That of the excretions is acid, contains earthy phosphates, and when evaporated, leaves a much larger residue than the fluid of the secretions. This residue is yellowish-brown, of the consistence of syrup, with an unpleasant sharp saline taste of the salts that it contains. It reddens litmus, is most soluble in alcohol, and this spirituous solution contains the muriates of the blood, together with free lactic acid, much lactate of soda (the soda being the free alkali of the blood, neutralised by this acid), and the extractive matter, which always accompanies this neutral salt. The part insoluble in alcohol contains a distinguishable quantity of phosphate of soda, a little of a similar animal matter to that found in the secretions, and also the earthy phosphates which were held in solution by the lactic acid, and were precipitated by the action of the alcohol. The urine possesses also a number of other substances, which will be specified when describing this excretion in particular." *

(B) It should be remembered that galvanic experiments prove solid matter able to traverse pieces of bladder and even of metals, wonderful and inconceivable as is the fact.

(C) Mr. Hodgson, on opening the body of a diabetic person, found the cavity of one renal artery obliterated by an accumulation of atheromatous and calcareous matter in its coats. The glandular structure was perfectly natural. The pelvis contained urine, and a considerable quantity of that fluid was found in the bladder. The kidney was supplied with blood by a large branch from one of the lumbar arteries and by the arteries of the renal capsule.†

(D) Every chemical change is a galvanic process, and secretion, being a decomposition and composition, must necessarily be connected with galvanism, which again, however, must be completely subservient to the vital power.

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* General Views of the Composition of Animal Fluids, by J. Berzelius, M.D. *Medico-chirurgic. Trans.* Vol. iii. p. 234.

† *A Treatise on the diseases of arteries and veins, &c.*

SECT. XXXIII.

OF THE FAT.

481. Of most of the secreted fluids, a concise and connected view of which was given in the last section, distinct mention has been made in its proper place: the rest will be described as opportunity may permit. Two remain, which cannot be discussed in a more proper place than the present,—at the close of our inquiry into the natural functions. The one—the fat, is a part of the system (4); the other—the urine, is excrementitious. We will examine each separately.

482. The *fat* * is an oily fluid, very similar in its general character to vegetable oils,† bland, inodorous, lighter than water; containing, besides the two elements common to water, to the oils just mentioned, and to wax, viz. carbon and hydrogen, sebacic acid,‡ which is pretty similar to the acetic.

483. When secreted from the blood and deposited in the mucous tela, it exists in the form of drops, divided

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* W. Xav. Jansen, *Pinguedinis Animalis Consideratio Physiologica et Pathologica.* Lugd. Bat. 1784. 8vo.

† J. D. Brandis, *Comm.* (rewarded with the Royal Prize) *de oleor. unguinosor. natura.* Gotting. 1785. 4to. p. 13.

‡ Joach. J. Rhades, *De ferro sanguinis hum. aliisque liquidis animalium.* ibid. 1753. 4to. ch. 4.

Dav. H. Knape (Præside Segnero) *De acido pinguedinis animalis.* ibid. 1754. 4to.

Laur. Crell, *Chemisches Journal.* 1778. P. i. p. 102.

by the laminæ of the tela, in a manner not unlike that in which the vitreous humour of the eye is contained in very similar cells.

484. The relation of fat to different parts is various. In the first place, some parts, even those whose mucous tela is extremely soft and delicate, never contain fat. Such are the palpebræ and penis.

In very many parts, it is diffused indefinitely, especially in the *panniculus adiposus*, the interstices of the muscles, &c.

In some few, it is always found, and appears to be contained in certain definite spaces, and destined for particular purposes. Such I consider the fat around the basis of the heart: * and in the mons veneris, where it forms a peculiar and circumscribed lump.†

485. Its consistence varies in different parts. More fluid in the orbit, it is harder and more like suet around the kidneys.

486. It is of late formation in the fœtus; scarcely any trace of its existence is discoverable before the fifth month after conception.

487. There have been controversies respecting the mode of its secretion: some, as Hunter, contending that it is formed by peculiar glands; others, that it merely transudes from the arteries. Besides other arguments in favour of the latter opinion, we may urge the morbid existence of fat in parts naturally destitute

* Hence it is clear how many exceptions must be made to the assertion of the celebrated Fourcroy,—that fat is an oily matter, formed at the extremities of arteries, and at the greatest distance from the centre of motion and animal heat. See his *Philosophie Chimique*. p. 112.

† I found it still more distinct in the body of a female of the species *simia cynomolgus*, from which, by means of cold, I was able to remove it entire.

of it;—a fact more explicable on the supposition of diseased action of vessels, than of the preternatural formation of glands. Thus, it is occasionally formed in the orbits; a lump of hard fat generally fills up the place of an extirpated testicle; and steotoms have been found in almost every cavity of the body.

The glands which some celebrated characters have contended secrete the fat, are not yet more than imaginary. Whatever may be the truth of this matter, the deposition and absorption of the fat take place with great rapidity.

488. The use of the fat is multifarious.

It lubricates the solids and facilitates their movements; prevents excessive sensibility; and, by equally distending the skin, contributes to beauty.

We pass over the particular uses of fat in certain parts, v. c. of the marrow of the bones.

During health, it contributes little or nothing to nourishment.* The modern opinion has more probability,—that it affords a receptacle for the superfluous hydrogen, which could not otherwise be easily evacuated.† (A)

NOTE.

(A) The fattest person on record is, I believe, Lambert of Leicester. He weighed seven hundred and thirty-nine pounds.

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* P. Lyonet conjectures with probability, that insects destitute of blood derive their chief nourishment from the fat in which they abound. *Tr. anat. de la Chenille qui ronge le bois de Saule.* p. 428. 483 sq. and the Preface. p. xiii.

† See Fourcroy, l. c.

In him rats and mice might certainly have nested, if it is true that a Bishop of Mentz, or

> "A Saxon Duke did grow so fat
> That mice, (as histories relate)
> Ate grots and labyrinths to dwell in
> His postique parts without his feeling." *

Excessive formation of fat may be strongly opposed by regularly taking great exercise, little sleep, and little, but dry, food.† Fretfulness of temper, or real anxiety of mind, will prevent any one from getting fat, and make any fat man thin. A passage that occurs in the most magnificent of Shakspeare's Roman plays and is founded on some information of Plutarch's, will instantly be remembered.

> *Cæsar.* Let me have men about me that are fat;
> Sleekheaded men, and such as sleep o' nights;
> Yond' Cassius has a lean and hungry look;
> He thinks too much: such men are dangerous.
> *Antony.* Fear him not, Cæsar, he's not dangerous;
> He is a noble Roman, and well given.
> *Cæsar.* 'Would he were fatter:—But I fear him not:
> Yet if my name were liable to fear,
> I do not know the man I should avoid
> So soon as that spare Cassius.‡

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* *Hudibras.* P. ii. Canto i.

† Semper vero et certissime debellanda, (obesitas) si modo bona voluntas et vis animi fuerit, valida corporis exercitatione, brevi somno, parca et sicca diæta. Nec facile miles gregarius repertus fuerit, qui tali morbo laborat. Gregory, *Conspectus Med. Theor.* LXXXIX.

See the instructive case of the Miller of Billericay, in the *Transactions of the Royal College of Physicians, London.* Vol. ii.

A large collection of cases of obesity will be found in Mr. Wadd's *Cursory Remarks on Corpulence.*

‡ *Julius Cæsar.* Act i. Sc. 2.

SECT. XXXIV.

OF THE URINE.

489. Besides the nutritious (4) fluids and those which form a part of our system, others are superfluous and excrementitious, commonly termed the excrements of the second digestion, and are of two orders. The one exhaled by perspiration, of which we treated formerly; the other—the *urine*, streaming from the kidneys.

490. The kidneys * are two viscera, situated at the upper part of the loins on each side, behind the peritonæum; rather flattened; more liable than any other organ to varieties of figure and number; † suspended by the emulgent vessels, ‡ which are excessively large in proportion to them; and imbedded in sebaceous fat. (485)

491. They are enveloped in a membrane of their own, which is beautifully vascular; and each, especially during infancy, consists of eight, or rather more, smaller kidneys, each of which again consists, as Ferrein asserts, of seventy or eighty fleshy radii, denominated by him pyramides albidæ.

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* See Al. Schumlansky, l. c.

† See Ger. Blasius, *Renum monstrosorum exempla,* at the end of Bellini, *de structura et usu renum.* Amstel. 1665. 12mo.

‡ Eustachius, *tabulæ,* 1—5, which belong to his classical work *De renibus,* published in this great man's *Opusc. anatom.* Venet. 1564. 4to. same edition. tab. xii.

492. A kidney, if divided horizontally, presents two substances; the exterior, called *cortex;* the interior, *medulla.*

Each abounds in blood vessels, but the cortical portion has likewise very minute colourless vessels which *secrete* the urine;* the medullary part contains those which *carry it off.*

These secreting ducts, arising from the arteries in the manner formerly described, (471) are united with glomerules which adhere to the cortical part and constitute the greatest portion of it. They may be readily distinguished by their angular course from the excreting or Bellinian tubes, in which they terminate. These, pursuing a straight course, run from the cortical to the medullary substance, which principally consists of them, and, after they have coalesced into fewer trunks, their mouths perforate, like a sieve, the *papillæ* of the pelvis of the organ.†

493. These papillæ usually correspond in number with the lobes which form the kidneys, and they convey the urine, secreted in the colourless vessels of the cortex and carried through the Bellinian tubes of the medulla, into the *infundibula,* which finally unite into a common *pelvis.*

494. The pelvis is continued into the *ureters,* which are membranous canals, very sensible, lined with mucus, extremely dilatable, generally of unequal size in the

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* These secreting ducts appear to have imposed upon Ferrein as a new description of vessels, which he called neuro-lymphatics or white tubes, and of which he imagined the whole parenchyma of the viscera to be composed. He affirmed that they were of such tenuity, that their length in each kidney of an adult man was equal to 1000 orgyiæ (60,000 feet) or 5 leagues.

† Eustachius, tab. xi. fig. 10.

human subject in different parts,* and inserted into the posterior and inferior surface of the bladder in such a way, that they do not immediately perforate its substance, but pass a short distance between the muscular and nervous coats, which at that part are rather thicker than elsewhere, and finally open into its cavity by an oblique mouth. This peculiarity of structure prevents the urine from regurgitating into the ureters from the bladder. (A)

495. The urinary *bladder*,† varying in shape according to age and sex, is generally capable, in the adult, of containing about two pounds of urine. Its fundus, which in the fœtus terminates in the urachus, is covered posteriorly by the peritonæum. The other coats correspond with those of the stomach.

The *muscular* consists of interrupted bands of fleshy fibres, variously decussated, and surrounding the bladder.‡ These are usually called the detrusor urinæ: the fibres which imperfectly surround the neck and are inconstant in origin and figure, have received the appellation of sphincter.

The *nervous* chiefly imparts tone to this membranous viscus.

The *interior*, abounding in cribriform follicles, § is lined with mucus, principally about the cervix.

496. The urine conveyed to the bladder, gradually becomes unpleasant by its quantity, and urges us to

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* See Nuck, *Adenographia.* fig. 32, 34, 35. Leop. M. Ant. Caldani, *Saggi dell' Accad. di Padova.* T. ii. p. 2.

† Duverney, *Œuvres anatomiques.* Vol. ii. tab. i.—iv.

‡ Santorini's posthumous tables. xv.

§ Flor. Caldani, *Opus. anat.* Patav. 1805. 4to. p. 5.

discharge it. For this purpose the *urethra* is given, which varies with the sex, and will be farther considered in our account of the sexual functions.

497. The bladder is evacuated from the constriction of the sphincter being overcome both by the action of the detrusor (495) and by the pressure of the abdomen. To these in men is superadded the action of the acceleratores, which force out even the drops of urine remaining in the bulb of the urethra.

498. The nature of the *urine* varies infinitely * from age, season of the year, the length of the period since food or drink was last taken, the quality of the ingesta,† &c. The urine of an adult, recently made after a tranquil repose, is generally a watery fluid of a nidorous smell and lemon colour, which qualities depend on a peculiar uric substance, besides a variety of other matters ‡ held by the water in solution and differing in their proportion in different persons. There is a remarkable quantity of phosphoric acid united with other constituents, forming phosphates of soda, ammonia, and lime. A peculiar acid—the lithic or uric, is found in the urine only. § (C)

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* See Hallé, *Mém. de la Soc. de Médec.* Vol. iii. p. 469 sq.

† The specific quality of some ingesta manifest themselves in the urine so suddenly, even while blood drawn from a vein discovers no sign of their presence, that physiologists have thought there must be some secret ways leading directly from the alimentary canal to the kidneys, besides the common channels. See v. c. Grimaud, *Sur la nutrition*, p. 115. Darwin, *Zoonomia.* vol. i. § 29. and Home, *Philos. Trans.* 1808. (B)

‡ See Fr. Stromeyer, *Theoret. chimie.* p. 609.

§ Consult on the analysis of the urine, among others, Berthollet, *Mém. de l'Acad. des Sc. de Paris.* 1780. p. 10.

Th. Lauth (præs. Spielmann), *De analysi urinæ et acido phosphoreo.* Argent. 1781. 4to.

H. Fr. Link,

NOTES.

(A) Mr. Charles Bell has described two long muscles running from the back of the prostate gland to the orifices of the ureters. Their action is not only to assist in emptying the bladder, but to pull down the orifices of the ureters, thus assisting to preserve that obliquity of insertion which the ureters have a tendency to lose in proportion as the bladder is depleted.*

(B) Sir Everard Home observed, in his experiments on the spleen, that colouring matters began to manifest themselves in the urine about seventeen minutes after they were swallowed, became gradually more evident, then gradually disappeared, and after some hours, when the mass had unquestionably passed into the intestines, again tinged it as strongly as ever.

(C) The following is Berzelius's analysis of urine.†

Water - - - - - - - -	933.00
Urea - - - - - - - -	30.10
Sulphate of potass - - - - - -	3.71
Sulphate of soda - - - - - -	3.16
Phosphate of soda - - - - - -	2.94
Muriate of soda - - - - - -	4.45
Phosphate of ammonia - - - - -	1.65
Muriate of ammonia - - - - -	1.50
Free lactic acid - - - - -	17.14
Lactate of ammonia - - - -	
Animal matter soluble in alcohol, and usually accompanying the lactates - - -	
Animal matter insoluble in alcohol - -	
Urea, not separable from the preceding -	
Earthy phosphates with a trace of fluate of lime	1.00
Uric acid - - - -- - -	1.00
Mucus of the bladder - - - - -	0.32
Silex - - - - - - - -	0.03
	1000.00

H. Fr. Link, *Commentatio* (honoured with the Royal Prize) *de analysi urinæ et origine calculi*. Gotting. 1788. 4to.

Fourcroy, *Annales de chimie*. T. vii. p. 180. and T. xvi. p. 113.

C. Fr. Gaertner, *Observata quædam circa urinæ naturam*. Tubing. 1796. 4to.

* *Med. Chir. Trans.* Vol. iii. † *Med. Chir. Trans.* Vol. iii.

It is a common mistake even at present to ascribe, as Blumenbach necessarily did, the colour and smell of urine to the urea, which is now known to be colourless and have an extremely faint, and by no means urinous, smell. Dr. Prout has established that urea consists of

Hydrogen - - - - - -	.266
Carbon - - - - - - -	.799
Azote - - - - - - -	1.866
Oxygen - - - - - - -	1.066
	4.000 *

The same physician has procured from lithic acid a curious substance which he denominates the purpuric acid.†

The urine of birds is generally discharged with the fæces, and becomes solid by exposure to the air. That of serpents is discharged only once in some weeks, is of a caseous consistence, and likewise becomes perfectly solid afterwards. Both are nearly pure uric acid.‡ The urine of the turtle and tortoise is also destitute of urea, but does not contain a great deal of pure uric acid. The analysis of the urine of brutes is highly interesting, but is not yet either extensive or accurate.

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* *Med. Chir. Trans.* Vol. ix.

† *Philos. Trans.* 1818.

‡ Dr. Prout, *Thomson's Annals of Philosophy*. Dr. Davy, *Philos. Trans.* 1818.

SECT. XXXV.

OF THE GENERAL DIFFERENCES OF THE SEXES.

499. Although the functions hitherto examined are common to both sexes, some are performed very differently in each. The most prominent differences shall be briefly reviewed before examining the sexual functions, properly so called.*

500. In general, each sex has its peculiar form; more or less striking after birth, but not very obvious in the young fœtus; for the genitals of the male and female, at this period, are not at first sight different, on account of the clitoris being remarkably large† and the scrotum scarcely formed.‡ (A)

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* Melch. Sebiz, *De differentiis corporis virilis et muliebris.* Argent. 1629. 4to.

F. Thierry, *præter genitalia sexus inter se discrepant.* Paris. 1750. 4to.

Dictionn. Encyclopéd. (Yverdon edit.) vol. xviii. art. Femme, and vol. xlii. art. Viril.

J. Fidel Ackermann, *De discrimine sexuum præter genitalia.* Mogunt. 1788. 8vo.

The same Writer's *Historia et ichnographia infantis androgyni.* Jen. 1805. fol. p. 61 sq.

P. Roussel, *Systême physique et moral de la Femme.* ed. 2. Paris. 1803. 8vo.

Ad. F. Nolte, *Diss. sistens momenta quædam circa sexus differentiam.* Gotting. 1788. 8vo.

J. Louis Moreau de la Sarthe, *Histoire naturelle de la femme.* Paris. 1802. 3 vols. 8vo.

Autenreith, *Archiv. für die Physiol.* T. vii. page 3 sq.

† Langguth, *Embryo* $3\frac{1}{2}$ *mensium qua faciem externam.* Viteb. 1751. 4to.

James Parsons, *Philos. Transact.* Vol. xlvii. p. 143.

Morgagni, *De sedibus et causis morborum.* xlviii. p. 10.

‡ This I lately found confirmed in twin abortions of different sexes and of

501. During infancy, the general figure is but little different, but becomes more so as age advances, when the round and plump breasts, the general conformation, the delicacy, softness, and the proportionally low stature of the female, form a striking contrast with the sinewy and robust body of the male.*

502. The relation of parts, in well-formed females, is somewhat different from that in the male. For instance, in the female the face is proportionally smaller; the abdominal and lumbar portion of the trunk longer; the hips broader, not, however, if well formed, broader than the shoulders; the buttocks larger; the legs in their descent gradually approach the knees. (B)

503. A similar difference is remarkable in the osseous system. In females, the bones are, cæteris paribus, smoother and rounder, the cylindrical more slender, and the flat thinner; to pass over individual differences, v. c. the very slight prominence of the frontal sinuses, the more elliptic edges of the alveoli, the greater narrowness of the chest, the greater capacity

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about sixteen weeks formation, in which, although they were most beautifully and correctly made, the difference of the genitals was not at first discoverable. In every other respect,—in the general figure, physiognomy, the dimensions of the loins, &c. they were perfectly similar.

* Consult, besides our great countryman Alb. Dürer, *Vier Bücher von menschlicher Proportion*. Nurenb. 1528. fol. the two celebrated male and female figures, painted by Titian or one of his school, in Vesalius's *Epitome suor. libror. d. c. h. anatome*. Basil. 1542. fol.

The three delineated by that excellent artist, Jer. Laidresse, in Bidloo, tab. i. ii. iii.

And Girardet's drawings in the *Cours complet d'Anatomie gravé par* A. E. Gautier *et expliqué par* M. Jadelot. Nantes, 1773. large fol.

on the contrary of the pelvis, the difference of the clavicles, thigh bones, &c.* (C)

504. With respect to the soft parts, the female mucous tela is more lax and yielding, so as to dilate more easily during pregnancy; the skin is more delicate, and of a clearer white, from the quantity of fat below it. The hair of the head is commonly longer: but other parts, which are covered with hair in men, are either quite smooth in women, as the chest and chin; or less hairy, as the perinæum; or smaller in circumference, as the pudenda; or covered with merely a very delicate and soft down, as the arms and legs. (D)

505. Among the particular differences of function, must be mentioned the pulse, which is, in females, cæteris paribus, more frequent (116); also the quantity of blood passing to the abdomen is greater. The lungs, on the other hand, are smaller, from the greater narrowness of the chest, which is however more moveable above. The os hyoides is much smaller; the larynx scarcely prominent and more contracted, whence the voice is less grave.

506. As to the animal functions, besides the greater abundance of nerves in the organs of *generation*, the general nervous system of females is far more mobile, and the propensity to emotion stronger. On the other hand, the muscular system is weaker, and the muscles (with the exception of the glutei, psoæ,

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* I have described these differences more fully throughout the sceleton in my *Osteological work.* p. 87 sq. ed. 2.

Compare Sömmerring's *Tabula sceleti fœminei.* Francof. 1796. fol. with the male figure in B. S. Albinus's *Tabulæ sceleti.* tab. 1.

quadrati lumborum, and a few others) proportionally smaller. (E)

507. In regard to the natural functions, the stomach and the appetite for food, are less;* the growth of the body more rapid; and the periods of dentition, puberty, and full growth, earlier.

508. But by far the greatest difference exists in the genital functions, which are intended in man for impregnating, and in woman for conceiving. The fuller investigation of these now remains to be prosecuted. (G)

NOTES.

(A) Sir Everard Home has published a singular hypothesis.† He suggests that the sex is not determined at the first formation of the individual, but that the parts of generation are originally so situated, and of such a nature, that they are capable of becoming either male or female organs when the sex is subsequently fixed. His arguments are the following.—1. The Testes and Ovaria lie originally in the same situation. 2. The Clitoris is at first of great size. 3. When the female among brute Mammalia has inguinal Mammæ, so likewise has the male; men also possess breasts. 4. The Scrotum occupies in the male, the place occupied in the female by the Labia, and is of the same structure with them. 5. The Nymphæ of the female exactly correspond

* Hence genuine and indubitable cases of long abstinence from food have generally occurred in females. (F)

See, among many others, Fl. James Voltelen, *Diatr. memorabilem septennis apositiæ historiam exhibens.* Lugd. Bat. 1777. 8vo.

† *Philos. Trans.* Vol. 89.

to the Preputium of the male. 6. Twins are usually of the same sex, as if the same cause had influenced the generative organs of each; when they are of different sexes, it is a common remark that they seldom breed, nature probably having been disturbed in her operations. 7. When among black cattle twins are produced of different sexes, that which appears the cow is really an hermaphrodite, incapable of breeding, and vulgarly termed a free martin;—a circumstance in every respect analogous to the preceding.* It may be added, that the round ligaments of the female descend, like the two spermatic chords of the male, to the abdominal ring; that marsupial bones exist, without any function whatever, in the males of some marsupial animals; that the hen has a Bursa Fabricii; and that the glans clitoridis of the female opossum is bifid. Comparative anatomy furnishes many similar facts. But the existence in both sexes of parts that can be useful only in one,—confessed by Paley to have been a complete puzzle to him,† is now universally regarded as merely an instance of Nature's observance of general rules in the formation of beings: ‡ even some *species* of animals have parts that are useful only in others, and so general are the laws of formation now found that naturalists are at this moment arranging all vegetables and animals in natural orders, and the artificial classifications of Linnæus are rapidly crumbling to dust. The resemblance of the Scrotum to the Labia, and of the Nymphæ to the Preputium, and the original identity of the situation of the testes and ovaria, may be similarly

* J. Hunter, *Observations on certain parts of the animal economy*. p. 55.

† *Natural Theology*. ch. 25. p. 472.

‡ "It shews in the function of generation an union of the *teleological* and *mechanical* principles, which were formerly thought to be incompatible with each other." In one sex we have "a clear instance of the teleological principle, i. e. a peculiar part formed for a certain purpose." In the other sex, "where the end and purpose of the part do not exist, we have the mechanical principle; as if the part had been merely framed in compliance with some general model for the structure of the species." Blumenbach, *Comparative Anatomy*. Ch. ii. § 38, 49.

explained. The usual identity of the sex of twins still shows only Nature's general plans, and the frequent infecundity of twins of different sexes only that general plans have been somewhat thwarted.

The sex of the offspring would appear determined by the female rather than by the male. Mr. Knight has observed that individual cows, &c. however various the males, produce one sex rather than the other, so that he has with tolerable certainty predicted the number of male and female young; while nothing similar was ever observable in regard to his bulls, rams, &c. Even the external appearance and the habits of brutes and vegetables, he has found much more, and sometimes altogether, influenced by the female. The quantity of pollen employed in the fecundation of female plants, he found of no importance in this respect.*

(B) The form as well as the texture of the female is more delicate: her surface has no muscular protuberances, but is beautifully rounded; her legs therefore have no calves, but, like the arms and fingers, gently taper; her feet and hands are small; her stature one sixth shorter than that of the male; her neck longer. From the smaller stature and the greater size of the abdominal and lumbar regions, it follows that the middle point which lies at the pubes in the male, is situated higher in the female. Her abdomen is more prominent and rounded, and her shoulders stand less forward and distant from the trunk. Her thighs are more voluminous and distant from each other.

(C) The greater capacity of the female pelvis, which contains the chief organs of generation and affords a passage for the child, arises from the greater expansion of the ossa ilei, the larger angle of the junction of the ossa pubis, and the greater concavity and breadth of the os sacrum: the os coccygis likewise is more slender and moveable. The clavicles are less bent; the thorax more projecting, whence deeper, although narrower and shorter; the sternum shorter and broader; the cartilago

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* *Philos. Trans.* Vol. 99.

ensiformis shorter; the two superior ribs flatter. Camper remarks, that if the male and female forms are traced within two ellipses of equal dimensions, the male shoulders will stand without and the pelvis within, while the female shoulders will remain within and the pelvis without.* The face and brain are absolutely smaller than in men, the face likewise proportionally so; yet such is the relative size of the cranium, that while in the male, the head, including the teeth, is as 1 to 8 or 10, in the female it is as 1 to 6, of the weight of the rest of the sceleton.

(D) Hen birds have a far less beautiful and copious plumage than cocks.

An instance is related by M. Roux of a woman forty years of age, who had one child and whose breasts were well developed, having a strong and long beard: the lobes of her ears were also covered with hair.†

(E) Inferior to man in reasoning powers and corporeal strength, woman possesses more sensibility of both body and mind, more tenderness, affection, and compassion, more of all that is endearing and capable of soothing human woes, but less firmness of character, except indeed where affection subsists;—although *Varium et mutabile semper fœmina,* is a true character, yet nothing is too irksome, too painful, or too perilous, for a mother, a wife, or a mistress, to endure or attempt for the object of her love.

"A thousand acts in every age will prove
Women are valiant in a cause they love.
If fate the favoured swain in danger place,
They heed not danger,—perils they embrace,
They dare the world's contempt—they brave their name's disgrace.
They on the ocean meet its wild alarms,
They search the dungeon with extended arms,
The utmost trial of their faith they prove,
And yield the lover to assert their love."

Crabbe, *Tales of the Hall.* xxi.

* *Mémoire sur le beau Physique.*

† *Anatomie descriptive,* par Xav. Bichat. T. v.

(F) And beastly gluttons are generally men.

(G) All the Linnæan classes of vegetables whose sex is known, are hermaphrodite, excepting Diœcia and in part Polygamia. Some inferior animals also are naturally hermaphrodite; and among others, for instance, moths, monstrous hermaphrodites are not uncommon, each half of the body possessing the characteristics of a different sex. There probably exists no authentic account of a true hermaphrodite, capable of impregnating and being impregnated, among mammalia. Yet occasionally brutes of this class have perfect organs of one sex combined with imperfect ones of the other, and both they and the human subject each set imperfect, so as to be truly neutrumque et utrumque.* Nor that in such combinations in the human subject at least one testis and one ovarium now and then exist, do I at all doubt, after reading the case given by Maret,† and seeing the creature shewn here lately under the name of Lefort. In the former, a testicle on one side and an ovarium on the other are decidedly said to have existed, besides vesiculæ seminales, a Fallopian tube, a uterus, a blind vagina, and a blind penis: from the middle upwards the general characteristics of the female were conspicuous, and from the middle downwards those of the male. Lefort had the general characteristics of each sex. The relative proportion of the trunk and extremities, that of the shoulders and pelvis, and the conformation and dimensions of the latter, were those of the male; the chin had as good a beard, and the breasts and extremities were covered with as abundant hair, as we usually observe in fair young men of the same age. Yet there were beautiful breasts with perfect areolæ and nipples, the hands and feet were small, and, like the other portions of the extremities, most elegantly tapering. Its unforeseen departure from London deprived me of the advantage of a second interview, but I fancy that the voice, face, cranium, and mental character were a mixture

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* *Phil. Trans.* 1799.

† *Mém. de l'Acad. de Dijon.* T. ii.

of those of both sexes. The eyes certainly sparkled with desire. Now had this been a man with imperfect organs, there might indeed have been the characteristics of the female strongly marked, but certainly not those of the male; and vice versa: nor would the eyes in either case have expressed the warmth of passion. On this account I am disposed to believe it in possession of at least one testis and one ovarium. The best judges in Paris pronounce it a woman; the best in London, a man. With respect to the genitals I own myself to have felt disinclined to examine them at a first interview, but understand there was a clitoris some millemetres in length—with an imperforate gland, and an urethra running along it inferiorly (a structure perhaps unknown in monstrous formation of simply female organs), and opening underneath by five small holes. A passage existed at the foot of the clitoris into which a catheter passed, but which afforded no urine. The catheter introduced into it might be directed downwards behind a membrane that united the labia below—where the opening of the vagina is commonly found, and would probably be divided with advantage, as the menses come through this passage. In fact both they and the urine pass through it and the five holes of the canal that is under the clitoris, and the urine is reported to come through both, although the catheter could bring none and neither passed into the bladder nor excited a desire to make water, if introduced into the lower canal. Whence there is probability in the conjecture that the urethra communicates with this passage within, by similar openings to those observed externally in its lower part.

Lefort has been seen to menstruate, and those who have not inspected the pudenda when visiting it at this period, have declared the countenance to be pale and languid as in a menstruating woman. It boasts of having menstruated ever since eight years of age, of having desires for each sex, and of being able fully to enjoy both. But a little exaggeration of this kind must be expected. The attendant told me that it had kept a young French girl some years. Whether seminal discharge takes place, is doubtful, as the communication between the testes (if there are any) and urethra may be deficient in some point. That it can derive any pleasure from sleeping with a male, except in the general contact, is impossible. On the contrary, the membrane that unites the labia must prevent coition and render every approach of the male organ extremely painful. No wonder, therefore, that, though its habits are feminine, (it does needle-work) perhaps in some measure from confinement, it has, morally indeed! chosen a girl for its associate. Independently, however, of these circumstances, I do not suppose that Lefort's beard and disgusting hairy breasts and limbs would easily procure a cavalier servente.

SECT. XXXVI.

OF THE GENITAL FUNCTION IN MAN.

509. The genital fluid is produced in the two testicles, which hang in the scrotum, by their *spermatic chords,* through a ring called abdominal, or through, more properly, a fissure in the tendon of the external oblique muscle of the abdomen. (A) Besides abundant lymphatics, three orders of vessels are found in the testes.—

The *spermatic artery,* which is, in proportion to the fineness of its caliber, the longest artery, by far, in the system, and usually conveys blood to the testicle immediately from the aorta.

The *ductus deferens,* which carries to the vesiculæ seminales the semen separated from the arterial blood.

The *pampiniform plexus* of veins, which return to the cava or renal vein the blood remaining after secretion. (B)

510. The testes are not always suspended in the scrotum. In the very young male fœtus, they are placed in an extremely different situation, the nature and successive changes of which were first accurately investigated by Haller,* but have since been variously stated; and the causes of this change of situation have given rise to numerous controversies. I shall derive

* Haller's Treatise *de herniis congenitis,* reprinted in his *opusc. patholog.* p. 311 sq. vol. iii. *Opera minora.*

my account of this subject from the natural appearances which I have preserved in a great number of small embryos, dissected by me with this view.

511. On opening the lower part of the abdomen of a young fœtus, there appears in each groin, at the ring of the oblique muscles, a very small opening in the peritonæum, leading downwards to a narrow passage which perforates the ring and runs to a peculiar sac that is extended beyond the abdominal cavity towards the scrotum, is interwoven with cellular fibres, and destined for the future reception of the testicle.

512. At the posterior margin of this abdominal opening, there is sent off another process of peritonæum, running upwards, and appearing, in the young fœtus, as little more than a longitudinal fold, from the base of which arises a small cylinder, or rather an inverted cone, which terminates above in a globular sac, containing the testis and epididymis, so that the testis, at first sight, resembles a small berry resting on its stalk, and appears hanging, like the liver or spleen, into the abdomen. (399)

513. The vessels which afterwards constitute the spermatic chord, are seen running behind the very delicate and pellucid peritonæum; the spermatic artery and vein descending along the sides of the spine, and the vas deferens passing inwards in the loose cellular substance behind the peritonæum towards the neck of the bladder. They enter the testis in the fold of peritonæum just mentioned.

514. After about the middle period of pregnancy, the testis gradually descends and approaches the narrow passage before spoken of (511), (the fold of peritonæum and the cylinder becoming at the same

time bent down) until it lies directly over the opening of the passage.

515. The testis being now ready for descent, the opening which was hitherto small, becomes dilated, so as to allow the organ to pass the abdominal ring and passage and to descend into the bulbous sac(511); after this occurrence, the opening soon becomes strongly closed and even grows together, leaving scarcely any vestige of itself in infancy.

516. In proportion to the slowness with which the testis proceeded towards the opening, does its transit through the abdominal passage appear rapid, and, as it were, instantaneous. It is common to find the testis in mature fœtuses either lying over the peritonæal opening, or, having passed this, resting in the groin; but I have once only met with the right testis, in a twin fœtus, at the very time when it was adhering, and in a manner strangled, in the middle of the passage, being just about to enter the sac; in this instance, the left testis had passed the abdominal canal and was already in the sac, and the abdominal opening was perfectly closed.

517. This remarkable passage of the testis from the abdomen through the groin, is limited to no period, but would seem to occur generally about the last month of pregnancy; the testicles are found, however, not very rarely in the abdomen or the upper portion of the groin at birth. For they have always another part of their course to finish, after leaving the abdomen, viz. to descend, together with their sac, from the groin into the scrotum.

518. Repeated observation demonstrates this to be the true course of the testicles. To assign the *powers*

and *causes* of its accomplishment is no easy matter. For I am every day more convinced that neither of the powers to which it is usually ascribed, viz. the action of the cremaster or diaphragm, or the mere contractility of the cellular membrane, interwoven with tendinous fibres, which adheres to the cylindrical process of peritonæum (512) and is called the Hunterian *gubernaculum,* is sufficient to explain so singular a movement, and least of all to explain the transit of the testis through the passage so often mentioned; but that the whole affords, if any thing does, a striking illustration of a vita propria, without the peculiar influence of which, so remarkable and unique a course, similar to no other function of the system, cannot even be imagined. (C)

519. The coats of the testes, after their descent, are conveniently divided into *common* and *proper*.

The common is the *scrotum,* consisting of the skin having a very moderate substratum of fat and differing from the rest of the integuments in this,—that it is continually changing its appearance, being sometimes lax and pendulous, sometimes (especially during the venereal orgasm and the application of cold) constricted and rigid, and, in the latter case, singularly marked by rugæ and furrows.

520. With respect to the coats proper to each testis, the *dartos* lies immediately under the scrotum, and is endowed with a peculiar and strong contractile power, which deceived the celebrated Winslow, Haller, &c. into the belief of the presence of muscularity. (D)

521. Next to this, with the intervention however of much soft cellular substance, are found three orders of

*tunicæ vaginales;** viz. an exterior, *common* to the testis and spermatic chord, and to which the *cremaster* muscle adheres by disjoined bundles of fibres; and two interior, one *proper* to the chord, and one to the testis; the fundus of the latter of which usually adheres to the common coat, but is internally moistened, like the pericardium, by a lubricating fluid. (E)

522. The origin of these coats,—the subject of so much controversy, may, I think, be readily explained, from the circumstances, already mentioned, attending the descent of the testis.

The *common* coat arises from the descending bulbous sac or peritonæal process. (511)

The *proper* coat of the *testis,* from that production of the peritonæum which, ascending from the cylinder (512), originally invests the testis.

The coat *proper* to the *chord,* from that fold and short cylinder of the peritonæum in which the fold terminates before it surrounds the testicle. (F)

523. To the body of the testis† there adheres very firmly, like the bark of a tree, a coat called *albuginea,* through the combination of which with the internal part of the vaginal coat, blood-vessels penetrate into the pulpy substance of the testis.‡ This pulpy substance is entirely composed of innumerable vessels, about a span in length § and convoluted into lobules, both con-

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* J. E. Neubauer, *De tunicis vaginalibus testis et funiculi spermatici.* Giess. 1767. 4to.

F. L. Eichhorn, *De hydrocele.* Gott. 1809. 4to.

† Alex. Monro fil. *De testibus et de semine in variis animalibus.* Edinb. 1755. 8vo.

‡ B. S. Albinus, *Annotat. Acad.* L. ii. tab. vii. fig. 1, 2, 3.

§ Vide Grew, *Museum Regalis Societatis.* page 7.

veying blood and secreting semen,* the latter of which is carried, through the rete vasculosum of Haller † and the vasa efferentia of de Graaf, to the apices of the cones of the epididymis.‡

524. The *Epididymis,* lying on the side of the testicle and consisting of one vessel about thirty feet in length, is smaller, and divided into about twenty glomerules or cones at the part called its head, § and is continued into the vas deferens, at its lower part, which gradually becomes thicker ‖ and is denominated its tail.

525. Each vas deferens, ascending towards the neck of the urinary bladder and converging towards the other under the prostate gland, is then directed backwards and dilated into the vesiculæ seminales, in such a manner, that the common mouth both of the vesicles and vasa deferentia opens into the urethra, behind the caput gallinaginis.**

526. The *vesiculæ seminales,* which adhere to the posterior and inferior surface of the bladder, surrounded by an abundance of fat, resemble two little intestines winding in various directions and branching into numerous blind appendices.

They consist of two coats, nearly similar to those of the gall bladder: the one strong, and of the description usually termed nervous; the other interior, deli-

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* The celebrated Sömmerring was so successful as to inject all the vessels composing the testis, and the entire head of the epididymis, with mercury. *Uber die körperl. Versch. des negers vom Europäer.* p. 38.

† Haller, *De viis seminis* in the *Philos. Trans.* No. 494. fig. 1. g. g.

‡ De Graaf, *De Viror. organis generationi inservientibus.* Tab. iv. fig. 1, 2.

§ Vide Alex. Monro fil. *Observations anatomical and physiological.* Edinb. 1758. 8vo. tab. i. E. E. E. F. G. H.

‖ B. S. Albinus, *Annotat. Acad.* L. ii. tab. iii. fig. 1.

** B. S. Albinus, l. c. L. iv. tab. iii. fig. 1, 2, 3.

cate, abounding in cells, and divided into compartments by prominent ridges, like those found in the cervix of the gall bladder.*

527. In these passages is slowly and sparingly secreted and contained after puberty, the *semen*, a very extraordinary and important fluid, of a milky yellowish colour,† of a peculiar odour, of the same viscidity as mucus, and of great specific gravity, of greater indeed than any other fluid in the body.‡

528. Semen has also this peculiarity, first observed by Lewis Hamme of Dantzic, in the year 1677,§—of being animated by an infinite number of small worms visible by the microscope, of the kind denominated infusoria, and of different figures in different genera of animals. In man,|| these *spermatic animalcules* are oval and have very fine tails: they are said to be found in prolific semen only, so that they are in some degree an adventitious criterion of its prolific maturity; I say adventitious, because I hope, after so many weighty arguments and observations,** there is no necessity

* See, besides the figures by Graaf, Haller, Albinus, and Monro, ll. cc. especially the beautiful one by Fl. Caldani in his *Opusc. Anat.* p. 17.

† The opinion of Herodotus respecting the black semen of Ethiopians, refuted in ancient times by Aristotle, has, to my surprise, been taken up in modern times by Le Cat, de Pauw, Wagler, &c.

‡ F. B. Ossiander asserts, "that fresh semen emitted under certain circumstances, is occasionally *phosphorescent.*" *De causa insertionis placentæ in uteri orificium.* Gotting. 1792. 4to. p. 16.

§ Vide Fr. Schrader, *De microscopior. usu in nat. sc. et anatome.* Gotting. 1681. 8vo. p. 34.

|| W. Fr. v. Gleichen, *Uber die Saamen-und Infusionsthierchen.* Nurenb. 1778. 4to. tab. i. fig. 1.

** Consult especially Laz. Spallanzani, both in his *Opuscoli di fisica animale e vegetabile.* Milan. 1776. 8vo. vol. ii. and in his *Dissertazioni, &c.* ibid. 1780. 8vo. vol. ii.

at present to remark, that they have no fecundating principle, and much less are the germs of future offspring. (G)

529. The genital fluid gradually collected in the vesicles is retained for subsequent excretion, and by its stay experiences changes nearly similar to those of the bile in the gall bladder,—becoming more inspissated and concentrated by the removal of its watery portion.*

530. As the whole of the testis and spermatic chord abounds in lymphatic vessels, which carry back to the blood a fluid with a seminal impregnation and thus facilitate the secretion of semen in the manner before described (477); so the vesiculæ seminales are likewise furnished with a similar set of vessels, which, by absorbing the inert watery part, render the remaining semen more powerful.

531. But I very much doubt whether the semen is ever absorbed during health; still more that it ever passes into the neighbouring veins; and most of all, that by this absorption, if it does occur, unseasonable venereal appetites are prevented, since, if we compare the phenomena of animals, procreating at particular periods, with the constitution of those which are castrated, we must conclude that this absorption is rather the cause of ungovernable and almost rabid lust.

* A parodoxical opinion was formerly entertained by some,—that the semen is not discharged from the vesiculæ seminales but from the vasa deferentia, and that the fluid of the vesicles is not truly spermatic and derived from the testis, but of quite another kind and secreted in peculiar glands belonging to the vesicles. This has gained some advocates among the moderns. J. Hunter, *On certain parts of the Animal Economy*. p. 27. J. A. Chaptal, *Journal de Physique*. Febr. 1787. p. 101. It has been refuted by Sömmerring, in the *Bibliotheca Medica* which I edited. vol. iii. p. 87. (H.)

532. I conceive that this end is accomplished in a very different mode, by a circumstance which occurs, as far as I have been able to discover, in no animal but man,—by *nocturnal pollutions,* which I regard as a natural * excretion intended to liberate the system from the otherwise urgent superfluous semen, more or less frequently, according to variety of temperament and constitution.†

533. The semen is never discharged pure but mixed with the *prostate fluid,* which is very much of the appearance of the white of egg, and has acquired its name from the organ by which it is produced,—an organ of some size, of a singular and very compact texture, lying between the vesiculæ seminales and bulb of the urethra, and commonly denominated *prostate gland.* The passages for the course of this fluid are not well known, unless perhaps they communicate with the sinus of the seminal caruncle, the middle of the orifice of which opens into the urethra ‡ between the two mouths (525) of the seminal vesicles.

534. The male *urethra* is the common outlet of three different fluids,—the urine, semen, and prostate liquor. It is lined with mucus which proceeds from numerous sinuses dispersed along the canal.§ We find it surrounded by a spongy texture, upon which lie two other

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* Chr. R. Jaenisch, *De pollutione nocturna.* Gotting. 1795. 4to.

† I willingly grant that barbarous nations, of a phlegmatic temperament and copulating promiscuously, do not require this excretion; but I must contend that it is a perfectly natural relief in a young man, single, sanguineous, full of juices, with a strong imagination, and living high, although enjoying the completest health.

‡ Morgagni, *Adversar. Anat.* iv. fig. 1, 2.

§ J. Ladmiral, *Effigies penis humani.* LB. 1741. 4to.

spongy bodies * of much greater thickness, constituting the greater part of the penis. The penis is terminated anteriorly by the *glans*—a continuation of the spongy texture, and usually covered by a delicate and very moveable skin, which is destitute of fat, and, at the corona of the glans, forms the preputium that moves over the gland as the eyelids do over the eyeball. The internal duplicature of the preputium, changing its appearance, is reflected over the glans, like the albuginea of the eye, and is beset at the corona with many Littrian † glands, similar to the Meibomian of the eyelids and secreting a peculiar smegma. ‡

535. The virile organ, thus constructed, possesses the power of *erection*,—of becoming swollen and stiff and changing its situation, from the impetuous congestion and effusion § of blood in its corpora cavernosa

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* Ruysch, *Observat. anat. chirurg. Centur.* p. 99. fig. 75—82. and *Ep. problemat.* xv. fig. 2, 4, 6, 7.

T. H. Thaut, *De virgæ virilis statu sano et morboso.* Wirceb. 1808. 4to. fig. 1.

† Morgagni, *Adversar. anat.* 1. tab. iv. fig. 4. i. k.

‡ This smegma in young men, especially when they are heated, is well known to accumulate readily and form an acrimonious caseous coagulum. The inhabitants of warm climates are particularly subject to this inconvenience, and the chief use of *circumcision* appears to be the prevention of this accumulation. We know that for this reason Christians in the scorching climate of Senegambia occasionally cut off the preputium, and that uncircumcised Europeans residing in the East frequently suffer great inconvenience. Guido de Cauliaco—the celebrated restorer of surgery in his day, who flourished in the middle of the fourteenth century, said that circumcision was useful to many besides Jews and Saracens, "Because there is no accumulation of sordes at the root of the gland, nor irritation of it." *Chirurg.* Tr. vi. doctr. ii. p. m. 111.

§ Vide Theod. G. Aug. Rooze, *Physiologische Untersuchungen.* Brunsw. 1796. 8vo. p. 17.

either by corporeal or mental stimulus, and of detumifying and collapsing after the return of the blood.* (I)

536. When in a flaccid state, it is considerably bent at its origin from the neck of the bladder,† and thus perfectly adapted for the discharge of the urine, but quite unfit for the emission of semen,‡ because the origin of the urethra then forms an acute angle with the openings of the seminal vesicles.

537. When the penis swells from desire, the prostate fluid generally flows first, and indeed is often discharged pure, though rarely together with the urine: its principal use is to be emitted with the semen, either by its albuminous lubricity correcting the viscidity of the former and promoting its emission, or contributing something peculiar to generation.

538. The emission of semen is *excited* by its abundance in the vesicles and by sexual instinct: it is *effected* by the violent tentigo which prevents the course of the urine and, as it were, throws the way open for the semen; by a kind of spasmodic contraction of the vesiculæ seminales; by a convulsion of the levatores ani § and of the acceleratores urinæ; and by a short and less violent succussion of the whole system, almost

* A phenomenon worthy of remark, even from the light which it promises to throw on this function in general, is the erection so frequently observed in those who are executed, especially if strangled. Consult, after Garmann's compiled farrago (*de Miraculis Mortuorum.* xi. 7 sq.), Morgagni, *De sed. et caus. morb.* xix. 19 sq. (K)

† See Camper, *Demonstration. anat. pathologic.* L. ii. tab. iii. fig. 1.

‡ Gysb. Beudt, *De fabrica et usu viscerum uropoieticorum.* LB. 1774. 4to. reprinted in Haller's *Collection of Anatomical Dissections.* T. iii. tab. iii.

§ Carpus on Mundinus, p. 190 b. and 310.

of an epileptic nature and followed by great depression of strength.* (L)

NOTES.

(A) Instances of more than two testes are extremely rare. Three, four, and even five, are said to have existed, and several authors declare that they themselves have seen three in individuals many of whose families were equally well provided.† Unless such cases are related by an experienced medical man from his own observation, they deserve no credit, and even then must be regarded with suspicion, if anatomical examination has not proved the additional bodies to be analogous to testes no less in structure than in form and situation. The late eccentric Dr. Mounsey, who ordered that his body should either be dissected by one of his friends or thrown into the Thames, was found to have in his scrotum a small steatom, which during life might have given the appearance of three testes.

The writers of such wonderful cases completely disagree in their account of the powers of these triorchides, tetrorchides, and pentorchides, some asserting them to be prodigious, others greatly below those of ordinary men.

One testis is commonly larger than the other, and, the right spermatic chord being for the most part shorter than the left, the right testis is generally the higher.

(B) The original situation of the testes accounts for the circumstance of their blood vessels arising from the loins, as Mr. Hunter remarked; for parts generally derive their vessels

* For which reason Zeno—the father of the Stoic philosophy, called the loss of semen the loss of part of the animating principle. (M)

† Dionis, *L'Anatomie des corps humains.* Demonstration quatrième. Sect. 1. Fernelius, Forestus, De Graaf, Borelli, &c. &c.

from the nearest source. The same applies to their nerves. Hence too the right spermatic artery frequently springs from the right renal as being nearer than the aorta, and the left spermatic vein frequently pours its blood into the left renal as being nearer than the inferior vena cava.

The original situation of the testes accounts also for the circumstance of the vas deferens arising from the lower part of the epididymis and bending upwards; in the fœtus this is not the case, but it is the necessary consequence of the subsequent change in the situation of the testes.*

C. The descent of the testes into the scrotum must, I apprehend, be owing to the growth of their nerves and vessels, and to the direction afforded by the contraction of the gubernaculum; the growth of the former, and therefore the whole process, is accounted for in the minds of some by the contraction of the latter.† Mr. Hunter's original account of the gubernaculum may not be unacceptable. "At this time of life, the testis is connected in a very particular manner with the parietes of the abdomen, at that place where in adult bodies, the spermatic vessels pass out, and likewise with the scrotum. This connection is by means of a substance which runs down from the lower end of the testis to the scrotum, and which at present I shall call the ligament or gubernaculum testis, because it connects the testis with the scrotum, and seems to direct its course through the rings of the abdominal muscles. It is of a pyramidal form; its large bulbous head is upwards, and fixed to the lower end of the testis and epididymis, and its lower and slender extremity is lost in the cellular membrane of the scrotum. The upper part of this ligament is within the abdomen, before the psoas, reaching from the testis to the groin, or to where the testicle is to pass out of the abdomen; whence the ligament runs

* J. Hunter, *A description of the situation of the testis in the fœtus, with its descent into the scrotum*, in his *Observations on certain parts of the animal economy*. p. 13.

† Bichat, *Anatomie descriptive*. T. ii. p. 234.

down into the scrotum, precisely in the same manner as the spermatic vessels pass down in adult bodies, and is there lost. That part of the ligamentum testis, which is within the abdomen, is covered by the peritonæum all round, except at its posterior part, which is contiguous to the psoas, and connected with it by the reflected peritonæum and by the cellular membrane. It is hard to say what is the structure or composition of this ligament: it is certainly vascular and fibrous, and the fibres run in the direction of the ligament itself, which is covered by the fibres of the cremaster or musculus testis, placed immediately behind the peritonæum. This circumstance is not easily ascertained in the human subject; but is very evident in others, more especially in those whose testicles remain in the cavity of the abdomen after the animal is full grown." *

(D) We know that the skin of every part relaxes by heat and contracts by cold, although it be not muscular: in the cold fit of an ague, it is constricted throughout so forcibly as to have acquired, during this state, the appellation of *Cutis Anserina.* The scrotum, being much more lax than any other portion of the skin, experiences these effects to the greatest extent. What is termed dartos is merely thick cellular membrane.

(E) Another coat, exterior to the rest, is described by M. Roux, and termed *Envelope fibreuse.* It is an elongated sac, large below to contain the testis and epididymis, and narrow above, affording a sheath to the chord. It vanishes among the cellular membrane of the ring.† M. Roux considers this coat as having been known to Haller, from the following passage in Haller's account of the testicle. "Ita fit ut interiores cavæ duæ sunt; superior vasculis spermaticis circumjecta; inferior testi propria." But Haller continues thus, "Ita sæpe se habet, ut etiam aquæ vis aut in partem testi propriam solam, intacta parte vasculosi funiculi, aut in istam solam, intacta testis vagina, effundatur, neque flatus impulsus de ea vaginali ad istam commeet.‡ He appears there-

* l. c. p. 6.

† Bichat's *Anat. Descrip.* T. ij. p. 176.

‡ *Elementa Physiologiæ.* T. vij. p. 420.

fore to describe merely the tunica vaginalis of the chord and testis.

(F) The cremaster deserves a little attention. This muscle arises from the superior anterior spinous process of the ileum, from the transversalis abdominis, the internal surface of the Fallopian ligament and neighbouring parts, and, passing through the ring, spreads upon the chord, vanishing upon the beginning of the testicle. Its office is evidently to support the testicle, and to draw it upwards against the groin during procreation. In those animals whose testes, instead of hanging in the scrotum, lie in the perinæum, in the groin, or in the abdomen, this muscle is, as might be expected, much less considerable.

It may here be mentioned that the human testes do not always descend into the scrotum, but occasionally remain, one or both, in the groin or abdomen. Individuals so circumstanced were called κρυψόρχιδες or testicondi by the ancients. A ridgil is a bull in which one only has descended. In these instances the generative powers are not impaired; a testicle which has not descended is prevented by the pressure of the neighbouring parts from fully evolving itself, but such persons, it is certain, "*militant non sine gloria.*"

The generative powers indeed are not impaired by the removal of one testis: the Hottentots have been said frequently to deprive their sons of one on arriving at eight years of age,* from the belief that monorchs are swift runners. We read in Varro, that if a bull is admitted to a cow immediately after both testes are removed, impregnation takes place,—"Exemptis testiculis, si statim admiseris, concipere (vaccas)."† This at least is certain, that some men have perfectly performed the act of copulation, though unfruitfully, after castration.‡ Many such accounts

* Wilh. ten Rhyne, *De promontor. Cap. bon. spei.* 22. pag. m. 64, and others quoted by Schurig, *Spermatologia.* p. 60.

† *De Re Rustica.* ii. 5.

‡ See Cabrolus, Philostrate, Scaliger *De subtilitate,* and Martin Schurig's *Spermatol.* Quoted in Very's *Histoire naturelle de l'Homme.*

are suspicious, but in a case mentioned by Mr. Astley Cooper in his surgical lectures as perfectly unquestionable, the complete power of coition positively remained some time after the removal of both organs by that surgeon, and gradually diminished.

The notion that each testicle, or each ovarium, is destined for the procreation of but one sex, is too nonsensical.

(G) Lewis Hamme, a young German, discovered the seminal animalcules, and shewed them to Leeuwenhoeck; and the sagacious Dutchman, catching eagerly at the discovery, published an account of them illustrated by plates. Hartzoeker, ambitious of the honor of the discovery, wrote upon the subject the following year, and asserted that he had seen the animalcules three years before they were observed by Hamme. The subject, being the very summit of filthiness, excited the earnest attention of all Europe. Physiologists, Naturalists, Popish Priests, Painters, Opticians, and Booksellers, all eagerly joined in the pursuit of the seminal animalcules, and the lascivious Charles the Second of England commanded them to be presented to him swimming and frisking in their native fluid. Some of the curious could not find them. Others not only found them, but ascertained their length was $\frac{3}{100000}$ of an inch, their bulk such as to admit the existence of 216,000 in a sphere whose diameter was the breadth of a hair, and their rate of travelling nine inches in an hour. They saw them too in the semen of all animals, and, what is remarkable, of nearly the same size and shape in the semen of the largest and of the smallest,—in the semen of the sprat and of the whale; they could distinguish the male from the female; in the semen of a ram, they beheld them moving forwards in a troop with great gravity like a flock of sheep; and in the human semen, Dalenpatius actually saw one indignantly burst its wormy skin and issue forth a perfectly formed human being. The little creatures would swim in shoals towards a given point, turn back, separate, meet again, move on singly, jump out, and dive in again, spin round and perform various other feats, proving themselves, if not the most delicate, at least the drollest, beings that ever engaged the attention of philosophers.

Their strength of constitution being an important object of enquiry, they gave proofs of their vigour not only by surviving their rough passage through the urethra, three, four, and seven days, but by impregnating a female at the end of this time, and, on being removed from her, by impregnating even a second. Sure never was so much folly and bestiality before committed under the name of philosophy.

Abr. Kauw Boerhaave, Maupertuis, Lieutaud, Ledermuller, Monro Secundus, Nicolas, Haller, and indeed nearly all the philosophers of Europe, were satisfied of the existence of the animalcules. Buffon and his followers, prejudiced in favour of an hypothesis, although they did not deny that the semen contained innumerable rapidly moving particles, contended that these were not animalcules but organic particles, and Linnæus imagined them to be inert molecules thrown into agitation by the warmth of the fluid. Their reality, however, might be regarded as established. But finally to determine the question, and accurately to ascertain every circumstance relating to them, the celebrated Spallanzani began a long course of observations and experiments about the middle of the last century, unbiassed in favour of any opinion, and endeavouring to forget entirely all that had been written upon the subject. The human semen he procured from bodies immediately after death, and that of animals either after death or during life.

He found in the former, innumerable animalcules with an oval body and a tail or appendix tapering to a point. This appendix by moving from side to side propelled them forwards. They were in constant motion in every direction. In about twenty-three minutes their movements became more languid, and in two or three hours they generally died, sinking to the bottom of the fluid, with their appendices extended. The duration of their life, however, depended much upon the temperature of the weather; at 2 below 0 (Reaumur) they died in $\frac{3}{4}$ of an hour; while at 7° they lived 2 hours; and at $12\frac{1}{2}$, 3 hours and three quarters. If the cold was not too intense, they recovered upon the temperature being raised; when only 3 or

4 below 0, they recovered after a lethargy of fourteen hours and upwards: and, according to the less intensity of the cold, they might be made to pass from the torpid to the active state more frequently. They were destroyed by river, ice, snow, and rain —water; by sulphur, tobacco, camphor, and electricity. Even the air was injurious to them;—in close vessels, their life was prolonged to some days, and their movements were not constant and hurried. They were of various sizes, and perfectly distinct from all species of animalcules found in vegetable infusions, &c. The seminal animalcules of different kinds of animals had generally each some peculiarity. In short, Spallanzani completely confirmed the principal observations of Leeuwenhoeck, and satisfactorily explained the sources of the inaccuracies of other enquirers.*

Although these beings are most numerous in the semen, he detected them occasionally in other fluids;—in the mesenteric blood of female frogs and salamanders, and in the blood of a tadpole and a calf.

It were to be wished that another Spallanzani would prosecute these enquiries.†

According to Vauquelin's analysis of the semen, 100 parts contain,

Of Water	9 . 0
Mucilage	6
Phosphate of lime	3
Soda	1

In some days it putrefies and becomes covered with the byssus septica.‡

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* *Opuscoli di Fisica animale e vegetabile.* Vol. ij.

† Creatures of an inch to an inch and a quarter in length, and of the same general shape as the seminal animalcules, inhabit the mesenteric arteries of asses, horses, &c. Mr. Hodgson found them in seven asses out of nine. (*A Treatise on the Diseases of Arteries and Veins, &c.*) To increase the wonder, the intestines of the human *embryo* have been found containing worms. Goeze, *Versuch einer naturgeschicte der Eingeweidwürmer.*

‡ *Annales de Chimie.* T. x.

(H) Mr. Hunter's arguments are the following. 1. "The semen, first discharged from the living body, is of a bluish white colour, in consistence like cream, and similar to what is found in the vasa deferentia after death; while that which follows is somewhat like the common mucus of the nose, but less viscid. The semen becomes more fluid upon exposure to the air, particularly that first thrown out; which is the very reverse of what happens to secretions in general. The smell of the semen is mawkish and unpleasant, exactly resembling that of the farina of a Spanish chesnut; and to the taste, though at first insipid, it has so much pungency, as, after some little time, to stimulate and excite a degree of heat in the mouth. But the fluid contained in these vesiculæ in a dead body, is of a brownish colour, and often varies in consistence in different parts of the bag, as if not well mixed. Its smell does not resemble that of the semen, neither does it become more fluid by being exposed to the air." On opening two men immediately after death, the contents of the vesiculæ were of a lighter colour than he usually found them in persons who had been some time dead, and in one of the instances so fluid as to run out upon cutting the vesiculæ, but they were similar to the semen neither in colour nor smell. An examination of the vesiculæ of the horse, boar, rat, beaver, and guinea-pig, afforded the same results. In the last animal, the contents near the fundus of the vesiculæ were viscid, and gradually firmer, till, near the opening into the urethra, they were as solid as common cheese, and no such substance could be detected in the vagina of the female after her union with the male. 2. During lasciviousness, the testicles swell, and they become painful, if the semen is not discharged; in coition, it may be added, they are drawn forcibly by the cremaster against the pubes, as if to assist the discharge of their contents at the period of emission. 3. In the old and debilitated, the vesiculæ are as full as in the young and vigorous. 4. Nay, in four men who had each lost a testicle, the vesicula on one side was equally full as on the other, although they had survived the operation a considerable length of time. The same was discovered in two cases, where, by mal-formation, one testicle had no communication with the corresponding vesicle. In the gelding and the stallion their contents are similar and nearly equal in quantity. The vas deferens has no communication in some animals with the vesiculæ, and in others, as the horse, where a communication does exist, the common duct is not of sufficient length to permit the regurgitation of the semen into the vesiculæ. 4. Some animals, especially among the carnivora, have no vesiculæ seminales, yet in their copulation they differ not from those which have. M. Richerand indeed asserts, that animals destitute of these organs are longer in coition than others, from having no reservoir for an accumulation of semen.* But he is mistaken. For on inspecting Cuvier's account of animals without and with vesiculæ, no connection whatever appears between their presence or absence and the length of copulation.

In opposition to these arguments it is urged, that a fluid gently propelled along the human vas deferens, does not pass into the urethra, but regurgitates into the vesicula.† But, granting this true, we have no proof that the secretion of the testes leaves the vasa deferentia except during emission, when this regurgitation is impossible. It may also be contended that, in cases of seminal weakness, the act of straining at the water-closet often instantly discharges from the urethra, without the least sensation, a large quantity of a fluid, which patients, who are of course unprejudiced in favour of any opinion, declare to be exactly similar, in colour, consistence, and odour, to that of a nocturnal emission. The compression cannot squeeze this fluid from the testes. If a partisan of Mr. Hunter should say that the *extremities* of the vasa deferentia afford it, we may reply to him that Mr. Hunter found them full of the same kind of fluid as the vesiculæ.

* *Elémens de Physiologie.* Chapitre x.

† Winslow, Ruysch, Duverney and others, quoted by Haller.

I believe, however, that we are unacquainted with the pure secretion of the testes, and that far the greatest portion of an emission is secreted by the vesiculæ seminales and prostate gland; and that therefore relaxed persons may, by forcing down, occasion a discharge apparently identical with an emission, though not containing a particle of matter furnished by the testes. The fact, already mentioned, of emission occurring for a long period after the removal of both testes,—till the removal had much deranged the whole genital system, forcibly corroborates this idea. The difference discovered by Mr. Hunter between the fluid found in the human vesiculæ seminales after death and that of an emission, is nothing more than might be expected if we were certain that they were the same,* and as the matter squeezed out in sexual debility exactly resembles that of a regular emission, this fact is fatal to Mr. Hunter's opinion, in regard to man, unless we relinquish the notion of the fluid of human emission being chiefly true semen from the testes. In different species of brutes the fluid of emission may be furnished in different proportions from the testes, vesiculæ, and prostate, and the effects of pressure and seminal debility in them are unknown.

(I) Accumulation of blood it is supposed may be produced in three ways. 1. By a mechanical impediment to its return: but there is no reason whatever to ascribe ordinary erection to compression. 2. By an increased flow of blood to a part, so that the vessels receive it faster than they convey it away. Here the vessels of the part itself in which the accumulation exists, are said by some to act more violently than usual; by others, the neighbouring larger vessels which supply these: their frequency of action, however, is not increased, but always remains correspondent with that of the heart. Were the vessels of the part itself to act more violently than usual, that is to say, to contract to a smaller and relax to a greater dimension than usual, (though an ordinary alternate contraction and relaxation is hypothetical)

* In the two men opened by Mr. Hunter soon after death, the vesicular fluid was actually much less brown than usual.

more blood would indeed subsist in them during their relaxation, but less than usual would subsist in them during their contraction, and there could be no accumulation, no inflammation. If the neighbouring large vessels act more violently than usual, (though their ordinary alternate contraction and relaxation are also hypothetical) they may be conceived to produce an accumulation of blood and a distention of the smaller vessels. 3. If the vessels of any part become dilated and do not contract in proportion, this circumstance will be sufficient to produce an accumulation, without any necessity for supposing an increased action of the neighbouring larger vessels. This explains inflammation: and in Bichat's *Anatomie Descriptive,* this explanation is given of erection. The corpora cavernosa which always contain florid blood, spontaneously dilate, and accumulation ensues. For this purpose it is not necessary that they should be muscular, but Mr. Hunter asserts their muscularity: in a horse he found them muscular to the eye, and they contracted upon being stimulated.

The heart, however, as in all cases of what is called increased determination of blood, lends its powerful aid by acting with augmented force.

As to the final cause of erection, the organ, by acquiring increased bulk, firmness, and sensibility, becomes adapted for affording and experiencing to the utmost extent the effects of friction both as exciting pleasure and as stimulating the secreting vessels; the increased length and narrowness of the urethra render the emission more forcible.*

(K) If Gall is right in placing the seat of sexual desire in the head, this kind of erection may be explained by supposing the irritation, arising in the cerebellum from the great accumulation of its blood, to produce a correspondent irritation in the organs

* Mr. Shaw has pointed out a venous network running along the inside of the urethra, but accumulated at what is called the membranous part, connected with the corpus spongiosum, and forming two columns with a groove in the middle. This must principally assist in narrowing the canal during erection, and, as the columns unite before the prostate, must also contribute to prevent the semen from moving towards the bladder. *Med. Chir. Trans.* Vol. x.

of generation: thus the epileptic paroxysm is not unfrequently accompanied by an emission. Nocturnal emissions occur most frequently after a person has been long in bed and supine,—the cerebellum the lowest part of the encephalon, if the occiput is, as usually, raised by a pillow. They may, however, be explained by the urine accumulating in the bladder during the continuance of repose and stimulating the generative parts connected with this receptacle the more readily in the supine posture, and this view is countenanced by the large quantity of urine generally made on waking after nature has been thus relieving the chaste unmarried man.

(L) The discharge of semen resembles the discharge of fluids from all glands. It is excited by the abundance of the fluid, by mental stimulus, or by mechanical irritation of the extremity of the excretory duct, for in such a point of view must be regarded the friction of the glans penis in copulation. The fluid is accumulated in the bulb of the urethra, since it must be accumulated somewhere to be emitted so copiously, and no other use can be assigned to the bulb; and if the vesiculæ do not receive it, no other part but the bulb can; besides, it is upon the bulb that the muscular contraction of the venereal paroxysm first acts. "The semen acting as a stimulus to the cavity of the bulb of the urethra, the muscles of that part of the canal are thrown into action, the fibres nearest the bladder probably act first, and those more forward in quick succession, and the semen is projected with some force. The blood in the bulb of the urethra is by the same action squeezed forward, but requiring a greater impulse to propel it, is rather later than the semen, on which it presses from behind; the corpus spongiosum being full of blood, acts almost as quick as undulation, in which it is assisted by the corresponding constriction of the urethra, and the semen is hurried along with a considerable velocity."*

(M) Zeno's practice was conformable to his principles. He

* Hunter, *Observations on the glands situated between the rectum and bladder, called vesiculæ seminales.* l. c. 45.

is recorded to have embraced his wife but once in his life, and then out of mere politeness.

Zenobia, the celebrated Queen of Palmyra and the East, was as extraordinary a wife. She never admitted her husband's embraces but for the sake of posterity, and, if her wishes were baffled, she reiterated the experiment in the ensuing month.*

Epicurus, Democritus, &c. were nearly of the same opinion with Zeno, and the Athletæ, that their strength might be unimpaired, never married. The Rabbies, in their anxiety to preserve their nation, are said to have ordered, with the view of preventing the loss of vigour, that a peasant should indulge but once a week, a merchant but once a month, a sailor but twice a year, and a studious man but once in two years.

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* *Augustan History*, quoted by Gibbon, *Decline and Fall, &c.* Vol. ii. p. 33.

SECT. XXXVII.

OF THE GENITAL FUNCTION OF WOMAN IN GENERAL.

539. As the male organs are fitted for affording, so the female organs are fitted for receiving, and are correspondently opposite to the former. In some parts, the organs of each sex are very analogous to each other in structure. Thus the *clitoris*, lying under the pubes in the superior commissure of the labia, agrees in many respects with the penis of the male, although distinct from the urethra and imperforate and extremely small in well-formed women. It is recorded to have been, in some adult females, of as comparatively large size as we stated it usually to be in the fœtus, (492) and these instances have probably given rise to most of the idle stories of hermaphrodites.* Like the penis, it has its corpora cavernosa, is capable of erection, is covered with a prepuce, and secretes a smegma † not dissimilar from the Littrian. (525)

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* Vide Haller, *Comment. Soc. Scient.* Gotting. vol. i. p. 12 sqq. Plates are given by Gautier in his *Observ. sur l'hist. Nat.* 1752. 4to.

† In warm climates it too is liable to accumulation and acrimony, and has hence been the occasion of the custom of female circumcision in many hot parts of Africa and Asia. Carst. Niebuhr has given a view, executed to the life, of the genitals of a circumcised Arabian female, eighteen years of age, whom he himself was singularly fortunate in examining during his oriental tour. *Beschreib. von Arabien.* p. 77 sq. and Osiander, *Denkwürdigkeiten für die Heilkunde*, &c. vol. ii. tab. vi. fig. 1.

540. From the clitoris the *nymphæ* descend, also occasionally of great size,* the source of other idle tales,† and, like the clitoris, possessing a high degree of sensibility. They appear in some measure to direct the stream of urine, because the *opening of the urethra*, which is very short in females, and frequently ciliated, as it were, with small papillary folds,‡ lies under their commencement.

541. Under the termination of the urethra lies the *opening of the vagina*, surrounded by various kinds of cryptæ, v. c. the lacunæ urethericæ of De Graaf, § and the orifices of the prostates, as they are improperly termed, of Casp. Bartholin, || which secrete an unctuous mucus.**

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* Their number has likewise occasionally varied. Vide Neubauer, *De triplici nympharum ordine*. Jenæ. 1774. 4to.

† I allude to the singular ventral skin of the Hottentot women. Wilh. ten. Rhyne, from personal inspection long ago, considered it as enormous pendulous nymphæ. *De promontorio b. spei*. p. 33. I have treated this point at large in my work, *De Gen. Hum. Var. Nat.* 242. ed. 3. (A) Steller relates something similar in regard to the Kamtschatkan women. *Beschr. v. d. Lande Kamtschatka*. p. 300.

‡ I find the opening of the urethra surrounded by very beautiful cutaneous cilia of this kind, in a remarkable specimen of the genitals of a woman upwards of eighty years of age. The hymen is entire, and all the other parts most perfectly, and, as it were, elaborately, formed. They are preserved in my museum, and my friend and colleague, Osiander, has represented them in a plate. Libro Citato. Tab. v.

§ See Jo. James Huber's plates of the uterus, among those of Haller. fasc. 1. tab. 2. fig. 1. g.

|| Ibid. fig. 1. b. b.—fig. 5. d.

** Such also are the two foramina, very frequently observed in living women by J. Dryander, at the extremity of the vagina. Nic. Massa, *Epistol. Medicinal.* T. i. page 123. b.

542. Across the opening of the vagina, the *Hymen** is extended,—a membrane generally circular, found, as far as I know, in the human subject alone, and of no physical use hitherto discovered.

The remains of the lacerated hymen become the *carunculæ myrtiformes,* which are of no regular number, and are infallible signs of the loss of virginity. (B)

543. The *vagina,* ascending between the urinary bladder and rectum, consists of a very vascular cellular parenchyma, is surrounded inferiorly by the *constrictor cunni,*† and lined internally with a very soft coat, which is marked by two *columns of rugæ,*‡—an interior and posterior,§ pouring forth a mucus into its cavity.

544. Upon the superior part of the vagina, rests the *uterus,* suspended on either side by its broad ligaments. Its cylindrical cervix|| is embraced by the vagina, and perforated by a narrow canal, which, like the vagina, is marked by rugæ denominated the arbor vitæ, and is generally lined with a viscid mucus at each extremity, but particularly at the superior.

545. The substance of the uterus is peculiar,—a very dense and compact parenchyma** abounding in blood-

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* John Wm. Tolberg, *De Varietate Hymenum.* Hal. 1791. 4to. Osiander, l. c. tab. 1.—vij.

† Eustachius, Tab. xiv. fig. i. xx.

Santorini, *Tab. Posth.* xvij. 1. 1.

‡ Huber, *De Vaginæ Uteri structura rugosa, necnon de Hymene.* GOTTING. 1742. 4to.

§ Vide Haller, *Icones Anat.* fasc. ij. tab. vj. fig. 1. 2.

|| Roederer, *Icones Uteri Humani.* tab. vij. fig. 2. 3. 4.

** J. Gotter. Weisse (Præs. Rud. Boehmer) *De Structura Uteri non musculosa, sed celluloso vasculosa.* Vitemb. 1784. 4to.

I. G. Walter, *Was ist Geburtshülfe.* Berlin. 1808. 8vo. p. 54.

vessels, which run in a curious serpentine direction* and are destitute of valves. It has also a supply of lymphatics,† and a great number of nerves,‡ whence its remarkable sympathy with other parts.

546. The uterus is covered externally with peritonæum; its internal cavity is small, and lined, especially at the fundus, with a soft and very delicate spongy membrane, which is composed, according to some, (92) of colourless arteries and veins, (92) and,§ according to others, of lymphatics.||

547. With respect to its muscularity, asserted by some** and denied by others,†† I may remark that I have never yet discovered a true muscular fibre in any human uterus which I have ever dissected, whether impregnated or unimpregnated, recent or prepared; but it must be allowed, that the fibres, termed by some muscular, have qualities very different from any others observable in the system. I am daily more convinced that the uterus has no true irritability, (301) but a vita propria, (42) correspondent with the peculiar motions and functions of the uterus, which are not referrible to

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* Id. *De Morbis Peritonæi.* tab. i. ii.

† Mascagni, tab. xiv.

‡ Walter, *Tab. Nerv. Thorac. et Abdom.* tab. 1. J. F. Osiander, *Commentatio præmio Regio ornata, qua edisseritur uterum nervos habere.* Goett. 1808. 4to.

§ Ferrein, *Mémoires de l'Acad. des Sc. de Paris.* 1741. p. 375.

|| Mascagni, l. c. page 4.

** See, for instance, Sue, *Mem. présentés.* vol. v.

L. Calza, *Atti dell' Acad. di Padova.* T. i. ii.

†† Walter, *Betracht. über die Geburstheile des weibl. Geschl.* page 25 sq.

Chr. H. Ribke, *über die Structur der Gebührmutter.* Berl. 1793. 8vo. but chiefly J. F. Lobstein, *Magasin Encyclopédique, redigé par* MILLIN. vol. XLIX. 1803. T. i. page 357 sq.

any properties common to the similar parts, (39-41) and which appeared to the ancient physicians and philosophers so peculiar, that the uterus was by them denominated an animal within an animal.* (C)

548. From the angles of the roof or fundus of the uterus arise on each side the *Fallopian tubes*†—narrow and tortuous canals, running in the upper part of the duplicature of the broad ligaments, similar in texture to the vagina, but internally destitute of rugæ, and lined by a very soft and delicate spongy substance.

549. The extremity which opens into the abdomen is not only larger than that which opens into the uterus, but is surrounded by laciniated, and, as it were, digitated *fimbriæ,* singular and elegant in structure, which are probably of great importance in conception, since they appear to become turgid as well as the tubes themselves, during the venereal œstrum, and to embrace the ovaria over which they lie.

550. The *ovaria,* or, as they were termed previously to the time of Stenonis,‡ the female testes, are composed of a tough and almost tendinous covering, and a dense and closely compacted cellular substance, which contains in each ovarium about fifteen ovula, called Graafian, viz. vesicles, or rather drops of albuminous yellow serum, which coagulates like white of eggs, if the recent ovarium is plunged into boiling water.

551. Such an albuminous drop appears to be what the female contributes in the business of conception,

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* I have spoken of these points at large in my treatise, *De vi vitali sanguini denegandu,* &c. Gott. 1795. 4to. p. 15 sq.

† Fallopius, *Observ. Anat.* p. 197.

‡ Stenonis was the first who asserted that the testes of women were analogous to an ovarium in 1667. *Elementor. Myologiæ Specimen.* page 117 sqq.

and it is probable, that, during the adult state, these drops become mature in succession, so that they one by one force their way and finally burst the covering of the ovarium and are received by the abdominal extremity of the Fallopian tube.

552. Besides the albuminous drop which escapes from the ovarium, another fluid, improperly styled *female semen* by the ancients, is poured forth during the venereal œstrum. Its nature, source, and quantity, are enveloped in no less mystery than its office.*

NOTES.

(A) Blumenbach states it to be a prolongation of the labia on the authority of Le Vaillant, but we are now certain that W. ten Rhyne was correct, and that it is a prolongation of the nymphæ,† which often hang five inches below the labia. The same tribe of Hottentot women have another connate singularity in the same quarter, common also to a variety of their sheep, and the source of all the charms of the Hottentot Venus—a brilliant example of denomination on the principle of *lucus a non lucendo.* Her immense and tremulous buttocks displayed on dissection an enormous accumulation of fat between the skin and muscles.‡

(B) Cuvier declares he has found the hymen in very many mammalia,§ overthrowing the doctrine, so strenuously maintained by

* Respecting this problematical fluid see Carpus on Mundinus, P. cxcviii sqq. and cccviij.

Harvey, *De Generatione Animal.* p. 95.

De Graaf, *De Mulierum Organis.* p. 194.

† Dr. Somerville, *Med. Chr. Trans.* 1816. Barrow, *Travels into the interior of Southern Africa.* v. i.

‡ Cuvier, *Mémoires du Museum.* T. 3. p. 269.

§ *Leç. d'Anat. comp.* T. v. p. 131-2.

Haller, of its existence for moral purposes. And, were it confined to the human female, the various size of its aperture and the various firmness of the organs, must ever leave those in uncertainty who can on their marriage indulge in sensual doubts. We read in Hume that Henry the Eighth, who certainly had his share of experience, boasted his discrimination; but in the east the difficulty was in ancient times proverbial. The lover of Italian literature who for the sake of great beauties is content to bear with much that is objectionable, knows how exquisitely natural is every description of Boccacio's, and will recollect his story of the daughter of the Sultan of Babylon:—"Essa, che con otto uomini forse diecemilia volte giaciuta era, allato a lui (al Re del Garbo) si coricò per pulcella, e fecegliele credere, che così fosse: e Reina con lui lietamente poi più tempo visse: e perciò si disse: Bocca basciata non perde ventura, anzi rinnuova, come fa la luna."*

(C) The muscularity of the uterus is allowed by Malpighi, Morgagni, Mery, Littre, Astruc, Ruysch, Monro, Vieussens, Haller, &c.

Mr. Charles Bell has a paper in the fourth volume of the Medical and Surgical Society, which it is necessary to quote freely, in order to give an accurate description of the muscular structure of this organ.

"The muscularity of the uterus is proved by direct ocular demonstration of the fibres in dissection, by the thickness of the fibres corresponding with their degree of contraction, by the visible action of the human uterus during life, by the resemblance of the laws of its contraction, (as felt and as perceived in its consequences) to those which govern the contraction of other hollow viscera, and lastly, by the vermicular and intestinal motions of the uterus, as seen in experiments upon brutes."

"The most curious and obviously useful part of the muscular substance of the uterus has been overlooked; I mean the mus-

* *Decamerone.* Giornata seconda. Novella vii.

cular layer of fibres which covers the upper segment of the gravid uterus. The fibres arise from the round ligaments, and regularly diverging, spread over the fundus until they unite and form the outermost stratum of the muscular substance of the uterus."

"The substance of the gravid uterus is powerfully and distinctly muscular; but the course of the fibres is here less easily described than might be imagined. Towards the fundus the circular fibres prevail; towards the orifice the longitudinal fibres are most apparent; and, on the whole, the most general course of the fibres is from the fundus towards the orifice. This prevalence of longitudinal fibres is undoubtedly a provision for diminishing the length of the uterus, and for drawing the fundus towards the orifice. At the same time these longitudinal fibres must dilate the orifice, and draw the lower part of the womb over the head of the child.

In making sections of the uterus while it retained its natural muscular contraction, I have been much struck in observing how entirely the blood vessels were closed and invisible, and how open and distinct the mouths of the cut blood vessels became when the same portions of the substance of the uterus were distended and relaxed." "A very principal effect of the muscular action of the womb is the constringing of the numerous vessels which supply the placenta, and which must be ruptured when the placenta is separated from the womb."

"Upon inverting the uterus and brushing off the decidua, the muscular structure is very distinctly seen. The inner surface of the fundus consists of two sets of fibres, running in concentric circles round the orifices of the Fallopian tubes. These circles at their circumference unite and mingle, making an intricate tissue. Ruysch, I am inclined to believe, saw the circular fibres of one side only,* and not adverting to the circumstance of the Fallopian tubes opening in the centre of these fibres, which would

* Discovered by Weitbrecht, and first accurately observed by Dr. Hunter.

have proved their lateral position, he described the muscle as seated in the centre of the fundus uteri. This structure of the inner surface of the fundus of the uterus is still adapted to the explanation of Ruysch, which was, that this produced contraction and corrugation of the surface of the uterus, which the placenta not partaking of, the cohesion of the surface was necessarily broken.

Further, I have observed a set of fibres of the inner surface of the uterus which are not described. They commence at the centre of the last described muscle, and having a course at first in some degree vorticose, they descend in a broad irregular band towards the orifice of the uterus. These fibres co-operating with the external muscle of the uterus, and with the general mass of fibres in the substance of it, must tend to draw down the fundus and lower segment of the uterus over the child's head.

I have not succeeded in discovering circular fibres in the os tincæ corresponding in place and office with the sphincter of other hollow viscera, and I am therefore inclined to believe, that, in the relaxing and opening of the orifice of the uterus, the change does not result from a relaxation of muscular fibres surrounding the orifice. Indeed, it is not reasonable to conceive that the contents of the uterus are to be retained during the nine months of gestation by the action of a sphincter muscle. The loosening of the orifice, and that softening and relaxation which precede labour, are quite unlike the yielding of a muscular ring."

SECT. XXXVIII.

OF THE MENSTRUA.

553. An important, and indeed the most frequent, function of the uterus, is to afford a menstrual fluid during about thirty years,—a law imposed upon no other species of animal:*—Woman, in the words of Pliny, is the only menstruating animal. The females of no nation, hitherto explored, are exempt from this law,† since it is among the requisites in the female sex for the propagation of the species.

554. The commencement of this function usually

* Most writers upon Natural History, and among the rest Buffon, allow the existence of menstruation in other animals, especially in the simiæ. But after carefully observing the females of the species of simiæ mentioned by him, (v. c. of the simia *sylvanus*, and *cynomolgus*, the papio *maimon*, &c.) for a number of years, I easily discovered that these supposed catamenia in some did not occur at all, and, in others of the very same species, were merely a vague and sparing uterine hemorrhage, *observing no regular period.*

† There is hardly occasion at present to refute the unfounded assertion, that in some countries, particularly on the Continent of America, the women do not menstruate. This opinion appears to have originated from the circumstance of the Europeans, who visited those countries and saw innumerable women nearly naked, never observing any menstrual stains upon them. For this there might be two reasons. First, the American women are, by a happy prejudice, regarded as infectious, while menstruating, and retire from society into solitary huts, to the benefit of their health. Again, their extreme cleanliness and the modest position in which they place their limbs would prevent any vestige of the catamenia from being observable, as Adr. Van Berkel expressly states, *Reisen nach Rio de Berbice und Surinam.* p. 46.

occurs about the fifteenth year, preceded by symptoms of plethora, by a sense of heaviness in the chest, and of tension in the loins, by lassitude of the limbs, &c. From the first of these symptoms, a reddish fluid generally flows from the genitals, becoming by degrees of a more bloody colour, and at length completely so. This has a peculiar odor, coagulates but imperfectly, and differs also in other respects from blood. It continues to flow slowly for some days, and the unpleasant symptoms above described in the mean time cease.

555. This red discharge returns after this period about every four weeks, and continues about six days, during which time a healthy woman is supposed to lose, perhaps, from five ounces to half a pound of blood.

556. This action is usually *discontinued* during pregnancy or suckling. It entirely *ceases* after existing about thirty years; and consequently, in our climate, about the forty-fifth year of age.

557. By some, the vagina, by others, and with more probability, the uterus, is considered the *source* of this discharge. Instances of women menstruating although pregnant or having the uterus imperforate or prolapsed, do not favour the former opinion, but only prove the extraordinary compensating powers of nature, who employs new ways, when the usual ones are obstructed. On the other hand, the dissection of many women who have died during menstruation, has discovered the cavity of the uterus bedewed with the catamenia.* I say nothing of the à priori argument—that the purpose of menstruation is probably to render the womb fit for

* See, for example, Morgagni, *Adv. Anat.* 1. tab. iii. M. M. M.

pregnancy and for nourishing the fœtus.* (A) On the same account, the arteries rather than the veins appear to be the source of the discharge.†

558. The investigation of the causes of the periodical return of this hemorrhage is so difficult, that we can obtain nothing beyond probability, and shall not dare to offer any thing merely conjectural.‡

The proximate cause is supposed to be a *local* § plethoric congestion,—an opinion with which the symptoms preceding menstruation, and the abundance and nature of the uterine vessels, agree very well.

Among the remote causes may be enumerated the erect posture peculiar to the human race, the peculiar parenchyma of the uterus, and its vita propria.

It will be better to confess our ignorance of the cause of its periodical return, than to indulge in vain hypotheses: for all the periodical phenomena of health and

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* L. H. Chr. Niemeyer, *De menstruationis fine et usu*. Gott. 1796. 8vo.

† J. Fr. Osiander, on the contrary, argues on the side of the veins, *Diss. de fluxu menstruo atque uteri prolapsu*. Goett. 1808. 4to. p. 14.

‡ Those who feel interested in this enquiry, may consult, among other writers, Abr. D'Orville, *Disquisitio* (Præs. Haller), *causæ menstrui fluxus*. Gotting. 1748. 4to.

Gisb. Verz. Muilman, *An ex celebrata hactenus opinione de plethora universali vel particulari vera fluxus menstrui causa explicari possit?* LB. 1772. 4to.

Theod. Traug. Jaehkel (Præs. Krause), *Aetiologia fluxus menstrui*. Lips. 1784. 4to.

§ The *universal* plethoric orgasm, as it was termed, which some formerly regarded as the cause of menstruation, has been long since refuted by more enlightened physiologists. To the arguments of the latter, I may be permitted to add the instance of the celebrated Hungarian sisters formerly mentioned (63. note), who from monstrous formation were united together. Although the same blood flowed in each on account of the union of the abdominal blood-vessels at the loins, they differed frequently both in the period and the quantity of their menstruation.

disease, *which continue more than twenty-four hours,* have hitherto appeared among the mysteries of animal nature.

NOTE.

I have known some women bear children before they had ever menstruated and others after menstruation had entirely ceased.

Neither is the pleasure of coition requisite to impregnation, for the mother of one of Napoleon's generals, as well as of other children, told a friend of mine "Qu'elle n'avoit eu que les douleurs d'enfanter," and the late Dr. Heberden has the following passage:—"Duo mariti mihi narrarunt uxores suas in venerem fuisse frigidas, omni ejus cupiditate et voluptate carentes; sæpe tamen gravidas factas esse, et recte peperisse." *

* *Commentarii de morborum historia et curatione.* Cap. 43.

SECT. XXXIX.

OF CONCEPTION AND PREGNANCY.

559. WE now come to the functions for which the genital organs are given us,—to conception and the propagation of the species, in treating of which, we shall first merely describe the phenomena that are observed in that admirable and truly divine process, and afterwards investigate the powers by which they are produced.

560. In the first place, it is worthy of remark that the human race, unlike most animals, does not copulate at certain periods of the year,* but that with it every season is equally favourable to the flame of love.

561. When a woman receives a man † and both burn with that animal instinct which is superior to all others in universality and violence, the uterus, swelling I imagine with a kind of inflammatory orgasm, ‡ and ani-

* Unless the observation first made by Wargentin, in Sweden,—that there is a greater proportion of births in September, which corresponds to the preceding December, be considered as relative to this point. *Swensk. Vetensk. Acad. Hadlingar.* 1767. vol. xxviii. p. 249 sq.

† Of the various circumstances of this admission, I have spoken in my work *De gen. hum. variet. nat.* p. 17 sq. ed. 3.

‡ v. the two instances seen by Ruysch, of uteri immediately after impregnation.—The one of a common woman, murdered by her paramour immediately after connection. *Adversar. Anat. Medico Chirurg.* Dec. i. tab. ii. fig. 3. The other of a married woman, impregnated a few hours previously, and killed in the act of adultery by her husband. *Thesaur. Anat.* vi. page 23 sq. tab. v. fig. 1.

mated by its vita propria (547), draws in, as it were, the semen ejaculated by the male,* and appears to pour forth a fluid of its own against it (552); the tubes become rigid, and their fimbriæ embrace the ovaria, in one of which a ripe Graafian vesicle bursts like an abscess, and its albuminous drop of fluid, being absorbed by the abdominal opening of the tube, is conveyed to the womb.

562. After the escape of this drop from the ovarium, the lips of the wound are closed by an external cicatrix, and the remaining vascular membrane is converted into a *corpus luteum*.† This is at first hollow, and full, as appears to me, of a plastic lymph, which in progress of time becomes a fleshy nucleus,‡ surrounded by a thick, remarkably vascular, cortex.§ (A)

563. After impregnation, the canal which runs along the cervix of the uterus, is thoroughly closed, espe-

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* If we consider the impetus with which the semen is emitted, and as it were swallowed by the uterus, and how small a quantity is proved, by experiments on animals, to be sufficient for impregnation, we shall be able to explain those well established cases of conception, where the hymen was imperforate,—cases brought forwards in support of the existence of a *seminal aura*.

† See J. Chph. Kuhlemann, *Observat. circa negot. generat. in ovib. factæ.* Gotting. 1753. 4to. *c. f. ae.*

‡ See W. Hunter, *Anatomy of the gravid uterus.* Tab. xv. fig. 5. tab. xxix. fig. 3. tab. xxxi. fig. 3.

§ It is a celebrated question of great importance both in physiology and forensic medicine, and much agitated in late years, whether a corpus luteum is the consequence of a fruitful coition only and therefore an infallible sign of conception, or whether it may occur independently of coition and therefore exist in virgins. I trust that I have established the truth of this point and shown the conditions under which a corpus luteum may occasionally be formed even in virgins. *Specimen physiologiæ comparatæ inter animantia calidi sanguinis vivipara et ovipara,* in the *Commentat. Soc. Reg. Scientar. Gotting.* vol. ix. p. 109 sq.

cially towards its superior or internal orifice (544), so that superfœtation, properly so called,* cannot naturally take place. There are scarcely any constant and infallible signs by which the woman herself can be very certain of the changes that occur within during conception.†

564. The internal surface of the uterus becomes lined with plastic, and, as it were, inflammatory, lymph (15), which forms the tunica *caduca* or *decidua* of Hunter.‡ This is said to consist of two laminæ,—the *crassa* investing the uterus except at the orifices of the tubes and of the canal of the cervix,§—and the *caduca reflexa,*|| so denominated from being, after the ovum begins to be formed and to take root in the decidua, continued over the other parts of the ovum, just

* That different conceptions may occur from the repetition of copulation after very short intervals, is proved by the instances of adulterous women who have brought forth twins resembling different fathers in the colour of their skin: viz. of black women who have brought forth a black and a mulatto, and of European women who have brought forth a white and a mulatto. (B)

† Ad. El. Siebold, *De diagnosi conceptionis et graviditatis sæpe dubia.* Wirceb. 1798. 4to.

Gm. Theoph. Kelch, *De symptomatibus et signis graviditatis earumque causis.* Regiom. 1794. 4to.

‡ Aretæus Cappadox (*De Causis et Sig. Morb. Diuturn.* L. ii. C. ii. p. 64 sqq. Boerhaave's edition) seems the first who gave a true account of the origin of this membrane, the more accurate knowledge of which we owe to Wm. Hunter.

After the revival of anatomy, Fallopius restored the knowledge of it. *Observ. Anat.* p. 207. It is the *chorion*, either simply called so, or the *spongy, tomentous, fungous, filamentous, reticulated* of the following age; the *involucrum membranaceum* of Albinus. The first view of it was given, as far as my knowledge extends, by Ruysch. *Thes. Anat.* v. tab. i. fig. 1. F. B. C. G.

§ W. Hunter, l. c. tab. xxxiv. fig. 3—6.

|| See B. S. Albinus, *Annotat. Acad.* L. i. tab. iii. fig. i. e.

W. Hunter, l. c. tab. xxxiii. fig. 1—4.

as the peritonæum is continued over the abdominal viscera.

565. The *ovum** is produced before the embryo which it is intended to contain, but scarcely begins to be formed earlier than the end of the second week from conception. Previously to this period, I very much doubt whether any vestige of human conception has ever been visible. (C)

566. This ovum consists, besides the external accessary covering afforded by the *caduca* of Hunter, of two proper velamenta or membranes.

Of an exterior—the *chorion*† of the moderns, the external surface of which is, from the first, nearly covered with inexpressibly beautiful knotty flocculi; whence it has been called the *flocculent*, *leafy*, or *mossy*, *chorion*. By means of these flocculi, which are the rudiments of the fœtal portion of the future *placenta*, the ovum takes root, as it were, in the uterine decidua. (564)

Of an interior—styled *amnion*, possessing no blood-vessels (5), delicate, but remarkably tough.

567. These two proper membranes of the ovum differ very much from each other in size the first week after the formation of the ovum; the chorion appears a large bladder, to which the amnion, like a much smaller

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* Respecting the membranes of the ovum and their connection with the uterus and embryo, vide J. F. Lobstein, *über die Ernährung des Fætus*. Halle. 1804. 8vo.

† The *Membrana media* of Rouhault, Haller, &c. For the various synonyms and homonyms of the membranes of the ovum, consult Haller, *Elem. Physiol.* Vol. viii. P. i. p. 194 sq. and Tabarrani's letter to Bartoloni, *Atti di Siena*. T. vi. p. 224 sq.

bladder, adheres in that part only which nearly corresponds with the centre of the external flocculent surface of the chorion.

The remaining space between the chorion and amnion is filled by a clear water, which may be called the *liquor chorii,* of doubtful origin and short duration.

For, since the amnion increases more rapidly than the chorion and approximates to the latter even during the first months after conception,* in proportion to its approximation must this fluid necessarily be absorbed.

568. The internal membrane of the ovum is filled, from its first formation (565) to the last moment of pregnancy, with the *liquor amnii,*† an aqueous fluid, of a yellowish colour, nearly inodorous, of a bland and scarcely saltish taste, commonly thought nutritious, and compared to albumen, from which, however, more accurate investigation proves it to differ considerably.‡

Its source is doubtful and cannot be referred to the fœtus or umbilical chord, because it exists in abortive ova containing neither.

Its quantity is inversely as the size of the fœtus. Hence we may conjecture that its use is rather to defend the fœtus while nearly gelatinous and most liable to suffer from external injuries, than to afford nourishment. That the portion of fluid which occasionally, although rarely, and therefore not naturally, enters the

* See Hunter's figures (imaginary indeed) l. c. tab. xxxiv. fig. 9. 8. 7.

† Paul. Scheel, at the end of his *Commentat. de liquoris amnii asperæ arteriæ fœtuum human. natura et usu.* Hafn. 1799. 8vo.

C. H. D'Zondi, *Supplementa ad anat. et physiolog. potissimum comparatam.* Lips. 1806. 4to.

‡ Steph. J. Van Geuns, *De natura et utilitate liquoris amnii.* Ultraj. 1793. 4to.

stomach of the fœtus, is not destined to nourish it, is evident from the nature of this fluid, and from the state of the chylopoietic system of the fœtus: to omit arguments deduced from acephalous fœtuses, &c.*

569. The embryo, which swims in this fluid, suspended by the umbilical chord, like fruit by its stalk, begins to be formed about the third week after conception: at first it appears of rather a globular shape, resembling a little bean or kidney, from which the rudiments of the extremities grow and the face is at length formed, &c.†

570. By nature, woman is *uniparous*, conceiving but one fœtus. Frequently, however, she produces twins, the proportion of which to single births, Süssmilch estimates as 1 to 70.‡ In these cases, each

* I trust no one will adduce in objection accounts of fœtuses destitute of umbilical vessels, who has read those accounts with any attention.

† There is no occasion in our times to refute the false remarks and figures, published by Mauriceau, Kerckring, and others, of fœtuses, one or a few days old.

The reasons of my fixing upon this term, I have explained at large in the *Medicin. Bibliothek.* vol. ii. p. 673 sq. How remarkably this was afterwards confirmed by fact, will be found in the same work. vol. iii. p. 727.

Those who have not an opportunity of inspecting the fragile primordia of our race, may consult the excellent plates in Ruysch's *Thesaur. Anat.* vi. tab. ij. fig. 2, 3, 4, 5, 8, 10. *Thesaur.* x. tab iii. fig. 1.

Also B. S. Albinus, *Annotat. Acad.* L. i. tab. v. fig. 4, 5.

Trew, *Commerc. Litter. Noric.* 1739. tab. iii. fig. 4, 5.

Abr. Vater, *Mus. anatom. propr.* tab. viij. fig. 2, 4, &c.

And, equal to them all, Sœmmerring's *Icones Embryonum Humanor.* Francof. ad Mœn. 1799. fol.

‡ The proportion is not very constant, and is liable to national variety. (D)

Egede expressly mentions the infrequency of twins among the Greenlanders, *Descr. du Grönland.* p. 112.

Their remarkable frequency, on the contrary, among the people of Chili is asserted by Molina, *Saggio sur la Storia Naturale del Chili.* p. 333.

child has usually its own amnion, whereas there is a common chorion.*

571. The medium of connection between the mother and child, are the umbilical chord and the placenta into which it is distributed.

572. The *umbilical chord,* which appears coëval with the embryo, varies exceedingly in length and thickness, in the place of its insertion into the placenta, in its varicose knots, &c. It generally consists of three blood vessels twisted spirally together, viz. a vein running to the liver of the fœtus, and two arteries arising from its internal iliacs or hypogastrics. They are separated from each other by cellular septa of various directions,† and are throughout narrowed internally by nodules or the *quasi-valves* of Hoboken. ‡

They are collected into a chord by means of a cellular membrane, which is full of a singular very limpid fluid called Whartonian, resembling gelatine in appearance, and is surrounded externally by a continuation of the amnion.

573. At the part of the chord which is united to the fœtus, there runs the *urachus,*§ which arises from the fundus of the urinary bladder and lies between the two umbilical arteries. In the human subject, it is pervious

* See Denman, *Engravings tending to illustrate generation and parturition.* Lond. 1787. fol. tab. ix.

Twins are very rarely contained in a common amnion. Vide J. de Puyt, *Verhandel. der Zeeuwsch Genootsch. te Ulissingen.* T. ix. p. 423 sq.

† W. Noortwyk, *Uteri Humani Gravidi Anatome.* tab. iii. fig. 5, 6, 7.

‡ Hoboken, *Anatome secundin. human. repetita.* p. 522 sq. fig. 38, 39, 40.

This structure is further displayed in the arterial branches of the placenta by Aug. Chr. Reuss, *Nov. Observ. circa Structur. Vasor. in Placenta Humana.* Tubing. 1784. 4to.

§ J. Noreen, *De Uracho.* Gotting. 1749. 4to.

Ph. Ad. Boehmer on the same, at the end of his *Anatome ovi hum. fœcund. sed deformis.* Hal. 1763. 4to.

but for a very short distance, and, indeed, soon disappears altogether. In other mammalia it leads to the allantoid,* which is universally acknowledged to be absent in the human fœtus. For I think that the problematical *vesicula umbilicalis,* found in human ova between the chorion and amnion,† is not analogous to the allantoid ‡ but to the *tunica erythroides* that is seen in the ova of some mammalia, and to the vitellary sac of the incubated egg. It is found in healthy human ova, the second or third month after conception, too frequently and of too constant an appearance to be regarded as accidental, morbid, or monstrous.§

* Vide Fabr. ab Aquapendente, *De Formato Fœtu.* tab. xii. xiii. xiv. xvii. fig. 27. xxv.

† Vide *Commentat. Soc. Reg. Sc. Gottingens.* vol. ix. p. 128. fig. 1.

‡ Among the moderns who have compared it to this, are J. F. Lobstein, l. c. *über die Ernährung des Fœtus;* and C. H. D'Zondi, *Supplem. ad Anat. et Physiol.*

§ The opinions both respecting the natural constancy of the vesicula umbilicalis and its analogy to the *tunica erythroides,* I originally, as far as I know, proposed upwards of twenty years since, in the first edition of these Institutions (1787), and in my *Specimen Physiologiæ Comparatæ* (1788) formerly quoted.

The connection of this vesicle with the intestinal canal of the embryo, and indeed with the appendix vermiformis of the cæcum, is shewn by Laur. Oken in his and Diet. G. Kieser's *Beytr. zur Vergleichenden Zoologie,* &c. Fasc. i. ii. Bamberg. 1806 sq.

See likewise Kieser's *Ursprung des Darmkanals aus der vesicula umbilicalis, dargestellt im menschlichen Embryo.* Goett. 1810. 4to.

But, on the contrary, Fr. Meckel shews it to be united with the diverticulum of the small intestines (Diverticulum Littrianum), *Beytr. zur vergleichenden Anatomie.* Vol. i. Fasc. i. Lips. 1808. p. 93; and more fully in Reil and Autenreith's *Archiv. für die Physiologie.* Vol. ix. p. 421.

Consult, among others, W. Hunter, *Anatomical Description of the Human Gravid Uterus* (a posthumous work edited by Matthew Baillie). Lond. 1794 4to. p. 40 sq.

B. N. G. Schreger's letter to Sömmerring, *De functione placentæ uterinæ.* Erlang. 1799. 8vo.

574. The blood-vessels of the chord pass to the *placenta*, of whose origin from the flocculent surface of the chorion that is united to the DECIDUA CRASSA, we formerly spoke. Hence we discover how the substance of the placenta is double,—the uterine portion derived from the decidua and forming a spongy parenchyma, the fœtal arising from the umbilical vessels distributed on the chorion. The increase of the ovum is irregular, the smooth part of the chorion growing more rapidly than the flocculent; consequently, the size of the placenta bears a greater proportion to that of the ovum, the shorter the period that has elapsed since conception, and a smaller, as the period of labour approaches.

As pregnancy advances, its texture becomes more compact; furrowed and lobular on its uterine surface, and smooth on the inner surface which is covered by the amnion. It varies greatly in size, thickness, figure, and situation, or place of attachment to the uterus; generally it adheres to the fundus; it is destitute of sensibility and true irritability.

575. Although all agree that the placenta is the chief instrument in the nourishment of the fœtus, the true mode of its operation, and its mutual relation to the uterus and fœtus, have given rise to great controversies in modern times. After all, the truth appears to be this,—that no anastomosis exists between the blood vessels of the uterus and of the chord, but that the oxygenised blood which proceeds from the uterus to the portion of the placenta that was originally the decidua crassa, is absorbed by the extreme radicles of the umbilical vein distributed upon the flocculent chorion, and carried to the great venous trunk of the

chord; while the carbonised blood returning from the fœtus, through the umbilical arteries, being poured in the same manner into the substance of the placenta, is absorbed by the venous radicles of the uterine portion of the placenta, and returned to the uterus.

This account is supported by very careful but fruitless attempts to inject the umbilical by means of the uterine vessels, and the uterine by means of the umbilical; or to tinge the bones of the fœtus with red, by giving madder to the mother during pregnancy. It is also confirmed by the difference observable between the blood of the mother and fœtus. (E)

576. During the progress of pregnancy, while the fœtus and secundines are increasing, the uterus of course undergoes important changes, not only in size, but in situation, figure, and especially in its texture, which is considerably changed both with respect to its blood-vessels and the intervening parenchyma, from the constant and great congestion of fluids that occurs.

In proportion as the uterus increases, the blood-vessels from being tortuous and narrow become more straight * and capacious, and the veins, near the termination of pregnancy, acquire so great a bulk † as to have been taken for sinuses by some anatomists.

The parenchyma becomes gradually more thin and lax, ‡ especially in the part nearest the ovum, so that although the gravid uterus is very thick, particularly at its fundus, and in a living and healthy woman is turgid with blood and replete with vital energy, never-

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* v. W. Hunter, *Anat. Uteri Gravidi.* tab. xvi.

† Ibid. tab. xviii.

‡ v. B. S. Albinus, *Annotat. Acad.* i. ii. tab. iii. fig. 2.

theless it is soft, and its general nature, (especially after death, when, as Arantius long since remarked, it almost appears lamellated if pregnancy was advanced,*) extremely different from the firm and compact substance of the unimpregnated uterus.

577. The remaining important changes† of the gravid uterus, as well as those still more remarkable ones which occur to the ovum and fœtus, we shall briefly relate in the order of the ten lunar months according to which pregnancy is at present very conveniently calculated.

578. As the uterus immediately after impregnation always becomes turgid, (561) so, increasing from that period in bulk and weight, it descends into the upper part of the vagina, still retaining its former figure dur ing the first three months, except, that, perhaps, its fundus becomes a little more convex and its anterior portion somewhat recedes from the posterior, and that its cavity, before extremely small and nearly triangular, becoming expanded by the fluids of the ovum, accommodates itself to their subglobular form.

The ovum itself, which about the termination of the first month is of the size of a pigeon's egg and posesses both deciduæ separate from each other and the minute amnion separate from the larger chorion, commonly attains, near the end of the third month, the size of a goose's egg; the decidua reflexa then closely approaches to the crassa, and the amnion to the chorion;

* Arantius, *De Humano Fœtu libellus*, p. 5 sq. 1579. Compare B. S. Albinus, *Tab. Uteri Gravidi.* ii.

† Among others consult J. Burns, *Anatomy of the Gravid Uterus.* Glasgow. 1799. 8vo.—a work carefully and faithfully executed.

the former is filled with the fluid which bears its name and defends from the pressure of the womb the tender embryo that is now very small in proportion to it, scarcely indeed equal to the size of a young mouse, and hanging headlong and rather unsteadily.*

579. From the fourth month, the uterus becomes more oval or subglobular, and, its neck gradually softening, shortening, and almost disappearing or rather distending laterally, it tends upwards and begins to rise to the superior part of the pelvis. At the same time the tubes ascend with the convex fundus of the uterus, and are extended and elongated, but adhere to the sides of this organ so firmly, that half of their length only is separate from it, and, at first sight, they appear to arise from the middle of it,—a circumstance which gave occasion to an erroneous opinion of the enormous increase of its fundus. After this period, the fœtus acquires a size more proportional to the capacity of the ovum, and becoming, at the same time, conglobated together, acquires a more fixed situation, which it preserves to the end of pregnancy; the head is inclined to the chest, and the back bent and generally placed rather towards one side of the mother.

580. In the middle of pregnancy,—at the end of the fifth month, so much has the uterus increased, that its fundus is nearly between the navel and pubes, and pregnancy becomes externally evident. From this period, the fœtus by its motion is generally more distinctly perceptible to the mother: this circumstance, however, occurs at no definite time.

* v. Doeveren, *Specimen. Observ. Academ.* p. 104 sq.

581. The uterus and fœtus continuing to increase during the remaining five lunar months, the fundus of the former reaches the umbilicus about the sixth month; after the eighth, having risen higher, it approaches the scrobiculus cordis. In the mean time, the cervix is gradually obliterated, flattened, and attenuated.

582. In the tenth month, the uterus, overwhelmed, as it were, with its own bulk,—being eleven inches in length and nine or more in breadth, begins to subside.

Each decidua, but especially the reflexa adhering to the chorion, having for many months been growing thinner, now almost appears a net-work of short white fibres.*

The larger diameter of the placenta is now nine inches; its thickness one inch; its weight one pound or upwards.

The length of the umbilical chord is generally eighteen inches or more.

The weight of a common full grown fœtus is usually seven pounds; its length about twenty inches.†

The quantity of the liquor amnii is too variable to be defined; but when the fœtus is strong, it seldom exceeds a pound.

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* On the various appearances of the decidua during the latter half of pregnancy, consult W. Hunter, *Anat. of the gravid uterus.* tab. xxiv. fig. 3, 4. tab. xxix. fig. 4, 5. comparing with these, tab. xxix. fig. 2.

† This weight and volume are remarkably large in proportion to the mother, if compared with those of the offspring of many other mammalia. But, notwithstanding this, woman is so far from producing the largest fœtus in this respect among the mammalia, that she is far surpassed by some, especially of the bisulca.

NOTES.

(A) The important contents of this and the preceding paragraph demand farther attention.

Several questions occur. 1. What is the state of the female organs during the vehemence of desire? 2. How far does the semen masculinum penetrate? 3. Do the Graafian vesicles burst from the influence of the semen masculinum, or from mere excitement, the semen impregnating only the contents of the vesicles after their escape from the ovaria? 4. At what period do the Graafian vesicles burst?

1. Mr. Cruikshank, on inspecting the genitals of a female rabbit during heat, observed appearances nearly similar to those described by Harvey, Graaf, Ruysch, Diembroeck, &c.* He found them all prodigiously turgid with blood; the vagina was absolutely of a dark mulberry colour, and on the ovaria were prominent spots which injection proved to be vascular and which were swollen Graafian vesicles; the contents of the vesicles, however, remained transparent: the Fallopian tubes were also nearly black, writhing in an extraordinary manner, having a strong peristaltic motion, and embracing the ovaria with their fimbriated extremity so closely as to lacerate on an attempt to disengage them.† These observations were all confirmed by Mr. Saumarez.‡ During copulation, this state of the organs must be carried to the highest pitch of intensity.

2. Harvey could never detect semen in the uterus after copulation.§ Nor De Graaf in the vagina.|| Verheyen found a large quantity in the uterus of a cow, six hours after copulation.** Galen always discovered it in the uterus of brutes after copu-

* Boerhaave, *Prælectiones Academicæ*, with Haller's notes. T. vi. p. 113 sq.

† *Philos. Trans.* 1797.

‡ *A new system of Physiology, &c.* Vol. i. p. 337.

§ Harvey, *De Generatione.* p. 228, &c.

|| Regn. De Graaf. T. i. 310.

** Verheyen, *Sup. Anat.* tract. 5. cap. 3.

lation.* Leeuwenhoeck, in the case of rabbits. Ruysch found it not only in the uterus, but in the Fallopian tubes of two women killed in the act of adultery.† Postellus, Riolan, Carpus, and Cheselden also believed they found it in the uterus.‡ Haller once found it in the uterus of a sheep, forty-five minutes after coition. § Fallopius frequently found it in the tubes. || Haller very justly remarks that some of those who believed they saw semen in the uterus, probably saw mucus only. He inclines, however, with almost all physiologists, to the opinion that the semen does enter the uterus. The length of the penis, the force of emission, the peristaltic action of the vagina during the heat of some brutes,** the existence of a bifid glans with two orifices in the penis of the males of some species the females of which have two ora uteri,†† are circumstances of no little weight in favour of the opinion that the semen does penetrate at least into the uterus. Mr. Hunter, however, actually saw it projected into the uterus of a bitch which he killed by dividing the spinal marrow while united with the male.‡‡

Dr. Haighton, with the view of ascertaining whether it is necessary to impregnation that the semen pass along the Fallopian tubes, made a number of experiments on the effects of tying and dividing them in rabbits at different periods relative to

* Galen, *De semine.* lib. i. c. 2.

† Ruysch, *Thes. Anat.* p. 90. tab. vi. fig. 1.

‡ Boerhaave, *Prælect. Acad.* Haller's note to p. 182. T. 6.

§ Haller, *Elementa Physiol.* T. 8. p. 22.

|| *Opera.* i. fol. m. 421.

** See, for instance, the *Med. Chir. Trans.* Vol. x. p. 266.

†† Account of the structure of the Wombat, by Sir E. Home. *Phil. Trans.* 1798.

‡‡ Home, *Phil. Trans.* 1817. Saumarez, l. c. p. 429.

Mr. Saumarez observed in two instances, when two hours and a half only had elapsed after coition, and before corpora lutea were formed, globular, pearl-coloured bodies as large as a pin's head, which, on being squeezed, burst and discharged a very subtle fluid to some distance. Dr. Haighton commonly met with them. Whether these were semen, having undergone some change, is uncertain.

The

coition.* The peristaltic action of the tubes and their adhesion to the ovaria during the venereal ardour, argue strongly in favour of the semen being conveyed along them, because we can hardly suppose these circumstances to begin to occur at this period for the purpose of conveying the contents of the Graafian vesicle, as this does not burst till a considerable time after copulation. Dr. Haighton, indeed, says that these changes in the tubes did not take place in his experiments till long (forty-eight hours) after copulation,—till the ovaria were about to discharge into them their vesicular fluids. In this he agrees with Bartholin, De Graaf, Schurig, Deswig, and Lang, who maintained, like him, that the semen, at least as far as examination went, does not enter the tubes.† But Mr. Cruikshank and Mr. Saumarez, two of the latest experimenters, assert the contrary in the detail of their experiments, and, as Haller remarks of the old partisans, the negative experiments of the former cannot overturn the positive testimony of the latter,—" Eorum experimenta *negativa* non possunt affirmantium fidem evertere:" Sbaragli,

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The well known instances of conception, where the admission of the male organ into the vagina was prevented by the great strength of the hymen, are sometimes cited against the opinion that the semen passes beyond the vagina, but certainly with no weight. 1. Because the most minute portion of semen is sufficient to impregnate:—Spallanzani mixed three grains of frog's semen with a pound and a half of water, and with this fecundated nearly all the numerous posterity contained in the threads taken from the female; and, after mixing three grains with even twenty-two pounds of water, he fecundated some. (*Dissertations.* vol. 2. p. 191. English transl.) 2. Because the vagina has an action of its own sufficient to move the semen onwards to the uterus:—it is seen during the œstrum of brutes (and also the uterus in a lower degree) to have a peristaltic movement, it often firmly embraces the human placenta, and Dr. Hamilton, the present obstetric professor of Edinburgh, mentions, in his lectures, having attended a physometric patient whose vagina sucked up air from without, as appeared from the emission of air ceasing in the warm bath; Dr. Monro secundus likewise was perfectly satisfied that the woman drew in the air.

* Experimental enquiry, &c. by John Haighton, M.D. *Philos. Trans.* 1797.

† Haller, *Elem. Physiol.* and notes to Boerhaave, l. c.

Verheyen, Hartman, and Duverney, could find no change in the state of the tubes at any time, although their negative observations are completely overthrown by the positive observations of all others who have enquired experimentally into the subject. Besides, the great abundance of blood in the genital organs, during the sexual ardour, must cause the tubes to enlarge and apply themselves to the ovaria: this, as Haller mentions upon the authority of Hartsoeker, occurs even in the dead body by means of injection.

Dr. Haighton, however, to prevent the semen from passing along the tubes, divided one of them in virgin rabbits, and, after the wound was healed, admitted the animal to the male. The ovarium on this side contained corpora lutea equally with the other, proving that the Graafian vesicles had burst, although the semen could not possibly have reached the ovarium.* No fœtus, notwithstanding, was discoverable in any instance: on the other side (for in the rabbit the uterus is double) fœtuses were found equal in number to the corpora lutea. Dr. Haighton concludes that impregnation may take place without the advance of semen along the tubes. And his conclusion is perfectly just, according to his test of impregnation,—the escape of the contents of a Graafian vesicle. But I apprehend this to be no more deserving the title of a test of impregnation than the emission of the semen masculinum. Impregnation is that change wrought by means of the male semen in the contents of a Graafian vesicle, which enables them to become a fœtus. Now this was never effected when the tube was divided:—although the presence of corpora lutea proved vesicles to have burst, yet a fœtus was in no one instance discovered: in other words, the contents of the Graafian vesicles

* The divided end of the tube was found totally impervious. The experiment succeeded when one tube only was divided: the division of both deprived the animal not only of fertility but of sexual desire, and even the division of one had this effect in some instances. If the tube was divided after coition, the result was the same, provided the operation was performed before the contents of the vesicles had entered it; for, if too much time had elapsed, the ova were transmitted to the uterus and grew to maturity.

were in no one instance impregnated. Hence I conclude, with the old physiologists before the time of Harvey, that the conveyance of semen beyond the vagina,—where it may come in contact with the contents of an ovarian vesicle, is absolutely requisite to impregnation; and perhaps the state of the tubes during the heat of some brutes (page 364), and the occasional growth of fœtuses in the tubes, abdomen, and in the ovaria themselves,* render it likely that the semen passes even into the tubes. But Dr. Haighton's experiments were unnecessary for this conclusion, because pathological observation proves sterility to be an invariable consequence of complete obstruction in any point between the os externum and ovaria,—in the Fallopian tubes, in the uterus, or in the vagina.†

When the obstruction in such cases is so far within as to allow the deposition of the semen, the sterility disproves the notion of Bartholin and Stenonis,—that this fluid operates by absorption.

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* The fœtus has frequently remained in the ovarium. See, for instance, the *Phil. Trans.* 1680-3. and 1797. also Schurig's *Embryologia.* p. 824 sq. where Bohn, Grundius, Ortlob, Blasius, and Littre, are quoted.

Such cases do not militate against the probability of the approximation of the semen masculinum to the ovarian contents being necessary for impregnation, because the tenuity of the vesicles, when ready for this operation, is such as we may suppose presents no barrier to the influence of the male upon the female fluid, especially if we reflect that oxygen and blood affect each other through a piece of bladder, (ii. F.). Indeed it is possible even that the vesicle bursts and the two fluids come into actual contact, but that imperfect rupture or some other cause detains the ovarian fluid till it has acquired permanent adhesions.

† Schurig, *Gynæcologia.* pars. ij. p. 172. Morgagni, Ruysch, &c. &c.

Dr. Blundel has lately repeated Dr. Haighton's experiments, with this unimportant variation, that he produced the obstruction not in the tubes, but in the uterus and vagina. Impregnation was of course equally prevented and the ovarian vesicles burst as usual. *Med. Chir. Trans.* vol. x.

3. Dr. Haighton imagines that the bursting of the vesicle is the sympathetic effect of the semen in the vagina or uterus.* Now although on the side where the tube was divided the ovarium did discharge the contents of some vesicles, it is not proved to have done this through the operation of the semen. The venereal ardor alone was shewn in the observations of Mr. Saumarez as well as in those of Mr. Cruikshank (and the same has been remarked in the human female) † to produce,

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* "That the semen first stimulates the vagina, os uteri, cavity of the uterus, or all of them.

"*By sympathy*, the ovarian vesicles enlarge, project, and burst.

"*By sympathy*, the tubes incline to the ovaria, and having embraced them convey the rudiments of the fœtus into the uterus.

"*By sympathy*, the uterus makes the necessary preparations for perfecting the formation and growth of the fœtus, and,

"*By sympathy*, the breasts furnish milk for its support after birth."

There is reason, however, from one passage, to suppose that Dr. Haighton believes the semen to pass no farther than the vagina. After dwelling upon the opinion opposite to his own, he says, "The difficulties which were opposed to the conveyance of the semen by the tubes, were, as we should expect, intended to prepare the way for a different explanation; therefore physiologists, by a very natural transition of thought, were led to suppose that the presence of semen in the *vagina alone* was sufficient to account for impregnation:" and he immediately proceeds to his experiments. In fact I know this to be his opinion, because in a MS. of his lectures which is full and accurate from having taken my notes in Latin, I find it said of Haller for believing that the semen always enters the uterus, "Now it is surprising that a man like Haller should do so, who, from his works would seem to form his opinions in general, on sound reasoning:" and Ruysch's cases are quite ridiculed because this anatomist, "being now of an age when most other people can see but little, set about looking for something wonderful, and discovered what nobody had ever seen before, viz. semen in the uterus and Fallopian tubes."

† In the body of a young woman, eighteen years of age, who had been brought up in a convent and had every appearance of being a virgin, Valisneri found five or six vesicles protruding in one ovarium, and the correspondiug Fallopian tube redder and longer than usual, as he had frequently observed in animals during heat. Bonnet gives the history of a young lady who died furiously in love with a man of low rank, and whose ovaria were turgid with vesicles of

among the other great changes of the sexual organs, the enlargement of the vesicles. Nay we are certain that it will occasion the rupture of the vesicle without any commerce with the male. The hens of poultry lay eggs (incapable indeed of being hatched), although separated from the cock,—a circumstance proving that in them the œstrum is sufficient to enlarge and burst a vesicle, apply the tube to the ovarium, and occasion it to convey away an ovum. Aristotle and Harvey relate that many birds lay eggs from mere titillation; the latter proved it experimentally in the thrush, in the sparrow, and in a favorite parrot belonging to his wife. Blumenbach * is satisfied with the accuracy of the accounts which he has read of corpora lutea in virgins, and since he wrote we have been furnished with abundant instances of their appearance in virgins not only of our own kind but of quadrupeds. Sir Everard Home † asserts that the corpus luteum is not a formation that fills up the cavity of a ruptured vesicle, but a substance in which the ovum is produced, and consequently no proof of conception. However this may be, the case remains the same; for he has repeatedly seen ovaria of both human and quadruped virgins that had discharged ova. Indeed he revives the old opinion of Kerckring, ‡—that ova are continually growing to maturity in succession and discharged. On this point I find it difficult in the present state of our knowledge to make up my mind, but I think it pretty evident that, although the semen has no share in bursting the ovarium, the high excitement of copulation contributes very considerably to it, since the inferior degree of excitement which occurs during the heat of brutes and in the lascivious states of the human

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great size. Blancaard, Schurig, Brendelius, Santorini, and Drelincourt, mention analogous facts. Haller's notes to Boerhaave's *Prælect. Acad.*

* *Spec. Physiol.* &c. anno 1788. quoted in his note to 562.

† *Phil. Trans.* 1819.

‡ *Anthrop. Ichnogr.* 1. 3. and 12. quoted by Schurig. "Tam conjugatæ quam virgines hæc ova sæpissime excernunt, insensibiliter quidem, quia non advertunt, nec quicquam de iis suspicantur."

virgin is sufficient frequently to effect the discharge of ova. It is perhaps impossible otherwise to explain the fact that ova are so commonly expelled from the ovaria and impregnated whenever a connection is arbitrarily or casually brought about. Hen pigeons, if kept with males, lay not only at an earlier age, but all the year round, instead of merely in the spring.

How the semen operates upon the ovarian secretion in fecundating and transmitting the paternal peculiarities, is a mystery impenetrably concealed from human curiosity.

4. The rupture of the ovarium has been said not to occur till some time subsequent to coition. Mr. Cruikshank did not see ova in the Fallopian tubes of rabbits, nor orifices in the corpora lutea, till the third day from copulation,* nor ova in the uterus till the fourth. Dr. Haighton never found any thing of a regular form in the uterus before the sixth day.

(B) An instance of superfœtation of the description granted by Blumenbach occurred to Mr. Blackaller of Weybridge. A white woman of very loose character left her husband, and some time afterwards returned pregnant to her parish and was delivered in the workhouse of twins, "one of which," says Mr. Blackaller in an account which he very handsomely sent me, "was born of a darker colour than I have usually observed the infants of negroes in the West Indies; the hair quite black with the woolly appearance usual to them, with nose flat and lips thick:" the second child had all the common appearances of white children.

The uterus has been sometimes wanting,† sometimes destitute of anterior opening,‡ and sometimes double,§ in which last case we may imagine superfetation possible at any period after the first conception, provided each uterus have a distinct

* De Graaf and Valisneri met with the same results.

† Lieutaud, Sandifort, Morgagni, Stein, Theden, Schmucker, Engel.

‡ Louis.

§ *Ephemerid. Natur. Curios.* Dec. 3. Ann. 7 and 8. Obs. 35. Cent. 9. Obs. 75. *Philos. Trans.* vol. 4. 1699.

orifice. It has frequently been removed after inversion, and several lives have lately been saved by this operation.*

A dissection is described by Dr. Granville † of a woman who had borne eleven children, male and female, and who died soon after being delivered of twins of both sexes. The right half only of the uterus was found developed, the left extending scarcely half an inch from the centre and shaped to a perfectly straight line: the left tube and ovary did not exist. This proves, if the proof were required, that one ovary is, like one testis, sufficient, not only for procreation, but for the procreation of offspring of both sexes. Dr. Granville thinks the case useful in proving also both that twins and twins of different sexes may come from the same ovary, contrary to the opinion of all physiologists, he says, except Sir Everard Home. The common fact, however, of three or four children being produced at a birth, sufficiently establishes the former conclusion.

As each fœtus, where there are more than one, may possess a separate placenta and chorion, and may come into the world solitarily, at some months distance perhaps from the other delivery, we see how easily practitioners may fancy a superfetation, when there is simply an expulsion of twins, triplets, &c. at different periods.

(C) Mr. Bauer has detected the human ovum on the eighth day from coition. It consisted of two membranes:—the external open throughout its length, but with its edges turned inwards, like shells of the genus voluta; the internal pointed at one end and obtuse at the other, slightly contracted in the middle, and containing, besides a slimy fluid, two globules that might be moved by pressure but quickly resumed their situations and were probably the rudiments of the heart and brain. ‡

(D) During 57 years, above 78,000 women have been deli-

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* Newnham, *on Inversio Uteri.* Davis, *ibid.* T. Windsor, *Med. Chir. Trans.* vol. x.

† *Phil. Trans.* 1818.

‡ *Phil. Trans.* 1817.

vered at the Dublin Lying-in-Hospital, and the proportion of women producing twins or more is about 1 in 57.

The proportion of males to females, about 10 to 9.*

(E) Fourcroy is almost the only author who has examined the blood of the fœtus,† and his observations, Berzelius remarks, "seem to have been made by chance, and not to be deduced from any experiment;" "credible authors have asserted that the eye cannot distinguish between the arterial and venous blood of the fœtus." ‡ Bichat could observe no difference in the arterial and venous blood of the umbilical chords of several guinea-pigs examined while the mother's respiration was still continuing after an opening had been made into the abdomen, "—les deux sangs offroient une noirceur egale." § So too in regard to dogs. ||

The chick, nevertheless, in the egg, cut off from all intercourse with the mother, requires its blood to be purified by the external air: for if the shell is varnished, the chick dies; and if, during the latter half of incubation, the shell is carefully opened, the chorion, to use the language of Blumenbach, presents one of the most splendid spectacles in the organic creation; the arteries are seen carrying blood of a bright scarlet, and the veins of a livid red.** The fœtus of the kangaroo has no vascular connection with the mother, being surrounded by a kind of jelly, and is supplied with external air by tubes opening into the uterus from within, for this express purpose.

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* John Cross, *Sketches of the Medical Schools of Paris.* p. 192.

† *Annales de Chimie.* T. vii. p. 162.

‡ *Animal Chemistry.* Translation, p. 41 sq.

§ *Récherches Physiologiques.* p. 271.

|| *Anatomie Générale.* T. ii. 344.

** *Comparative Anatomy.* Translated by Mr. Lawrence. § 372.

SECT. XL.

OF THE NISUS FORMATIVUS.

583. HAVING simply described the phenomena of conception and the changes which constant observation proves to occur both in the ovum and the contained fœtus during pregnancy, we now proceed to those powers by which it appears that generation is effected.

584. Even in our memory, some physiologists of reputation have contented themselves with roundly asserting that true generation never occurs, but that the whole human race pre-existed in the genitals of our first parents, in the shape of previously-formed germs which become evolved in succession. Some of these imagined the germs to be the spermatic animalcules of the male;* others imagined them to exist in the ovaries of the mother.†

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* See W. Fr. v. Gleichen, l. c.

† v. c. The illustrious Haller, who plainly asserted, *that all the viscera and even the bones of the future fœtus, nearly fluid indeed, and therefore invisible, were pre-formed, before conception, in the maternal germ.*

In support of this hypothesis, he argued chiefly from the continuity of the membranes and blood-vessels between the incubated chick and the yolk of the egg. *Opera Minora.* T. ii. p. 418 sq.

But the more frequently I have demonstrated the phenomena of incubation in my Physiological Lectures, the less strength have I found in this argument. Nor can I sufficiently wonder how this great physiologist could so constantly reject, as almost absurd, the inosculation, properly so called, of the vessels of

585. This hypothesis of the successive evolution of germs pre-formed from the creation, must, if carefully examined, be rejected.* Not only is the superfluous and useless creation, which is supposed, of innumerable germs never arriving at evolution, repugnant to reason, but so many preternatural conditions † and such a multiplication of natural powers ‡ are assumed, that it is perfectly irreconcileable with sound physiology.

Add to this, that, of the phenomena adduced in its favour, no one is sufficiently consonant with truth to establish the hypothesis.§

On the other hand, we have indubitable observations which refute it directly and completely.

586. The less this hypothesis of evolution, as it is commonly termed, is found consonant with fact and the rules of philosophising, the more strongly does the opposite opinion recommend itself to our notice by its simplicity and correspondence with nature, supposing, as it does, not an evolution of fictitious germina by conception, but a true and gradual formation of a new conception from the hitherto formless genital matter.

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the chick with those of the yolk, while at the same time he admitted and defended a perfectly similar inosculation in the connection of the human ovum with the gravid uterus. *Elem. Physiol.* Lausanne. 1788. T. viii. P. i. p. 94, comparing p. 257.

* See L. P. *Zweifel gegen die Entwickelungstheorie.—Aus der Französischen Handschrift von* G. Forster. Gotting. 1788. 8vo.

† v. Kant's remarks on these, *Critik der Urtheilskraft.* p. 372.

‡ This defect I have shewn at large, *Handbuch der Naturgeschichte.* p. 15 sq. 8vo. 1807.

§ Those who desire a fuller demonstration of this and other assertions but briefly noticed in the present section, I refer to the work *über den Bildungstrieb.* 3d edit. Gotting. 1791. 8vo.

587. This true generation by successive formation has been variously described by physiologists, but the following we consider as the true account.

1. The *matter* of which organised bodies, and therefore the human frame, are composed, differs from all other matter in this,—that it alone is subject to the influence of the vital powers.*

2. Among the orders of vital powers, one is eminently remarkable and the least disputable of all, which, while it acts upon that matter, hitherto shapeless but mature, imparts to it a *form* regular and definite, although varying according to the particular nature of the matter. To distinguish this vital power from the rest, permit us to designate it by the term—NISUS FORMATIVUS.

3. The nisus formativus occurs to the genital *matter*, when this is mature and committed to the uterus in a proper condition and under proper circumstances, lays in it the rudiments of conception, and gradually *forms* organs fitted for particular purposes; preserves this structure during life, by nourishing (455 sq.) the body; and reproduces, (459) as far as it can, any part accidentally mutilated.†

588. We therefore think it very probable that those fluids which, during a successful coition, are thrown

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* See Chr. Girtanner, *über das Kantische Prinzip für die Naturgeschichte.* Gotting. 1796. 8vo. p. 14 sq.

† Here allow me to make three remarks.

1. I have used the expression—nisus formativus, merely to distinguish it from the other orders of vital powers, and by no means to explain the *cause* of generation, which I consider equally involved in Cimmerian darkness as the cause of gravitation or attraction that are merely terms given to effects known, like the nisus formativus, à posteriori.

into the cavity of the uterus, (527, 533, 551.) require a certain period for becoming intimately mixed, acted upon, and matured; that, after this preparatory stage, the nisus formativus is excited in them, vivifying and shaping the hitherto shapeless spermatic matter partly into the beautiful containing ovum (565) and partly into the contained embryo; (569) and that this is the reason of our inability, notwithstanding the present perfection of optical instruments, to discover, during the first weeks after conception, any thing more than shapeless fluids, without the faintest trace of the form of an embryo, which, however, about the third month, suddenly, as it were, becomes observable.

589. We should exceed the limits of these institutions, were we to adduce many of the arguments which may be drawn from facts, to illustrate, as, in our opinion, they most clearly do, the great influence of the nisus formativus in generation. We will, however, venture to mention, as briefly as possible, a few, whose weight will, on a little close reflection, be sufficiently evident.

590. Such, in the history of *hybrid* animals, is the

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2. The word NISUS I have adopted chiefly to express an energy truly vital, and therefore to distinguish it as clearly as possible from powers merely mechanical, by which some physiologists formerly endeavoured to explain generation.

3. The point on which the whole of this doctrine respecting the nisus formativus turns, and which is alone sufficient to distinguish it from the vis plastica of the ancients or the vis essentialis of the celebrated Wolff and similar hypotheses, is *the union and intimate co-exertion of two distinct principles in the evolution of the nature of organised bodies,—of the* PHYSICO-MECHANICAL *with the purely* TELEOLOGICAL,—principles which have hitherto been adopted but separately by physiologists in framing theories of generation.

singular experiment of impregnating those which are *prolific*, for many generations, with male semen of the same species, by means of which the form of the young hybrids becomes so progressively different from the original maternal configuration, as to approach more and more to that of the father, till, by a kind of arbitrary metamorphosis, it is absolutely converted into it.*

591. Such in our knowledge of *monsters* (which, according to the hypothesis of evolution, are nearly all maintained to have pre-existed in the germs from the first creation), is the well known fact—that among certain *domestic* species of animals, and especially among sows, monstrosities are very common, whereas in the original wild variety they are extremely uncommon.

592. While the phenomena of *reproduction* are all much more explicable by the nisus formativus than by the pre-existence of germs for every part, some particular instances (v. c. that of the nails, which, after the loss of the first phalanx of the fingers, have been known to be reproduced on the neighbouring middle phalanx,†) admit evidently of no other solution.

593. From an impartial view of each side of the question, it will clearly appear, that the defenders of the germs must allow to the male semen, not only an *exciting* power, as they do, but likewise great *formative* powers, and thus their doctrine stands in need of the

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* Jos. G. Kölreuter, *Dritte Fortsetz. der vorläuf. Nachr.* p. 51 sq.

† Tulpius, *Observat. Med.* L. iv. c. 56.

assistance of the nisus formativus; while our explanation, on the contrary, is sufficient, without the aid of pre-existing germs, to explain the phenomena of generation. There can consequently be no reason for multiplying the *entia*, as they are called, unnecessarily. (A)

NOTES.

(A) The *nisus formativus* produces a being generally resembling the parents, but occasionally different. This subject will be fully treated of in the note on the varieties of mankind.

It is not probable that the ardor of the procreants affects the energy of the offspring. But from the days of Aristotle it has been remarked that bastards are very frequently endowed with great genius and valour, and both ancient and modern history certainly afford many such examples; and the circumstance has been commonly ascribed to the impetuosity of the parents during their embraces. Shakspeare, in King Lear, introduces Edmund bursting into this indignant soliloquy:—

> "Why bastard? wherefore base?
> When my dimensions are as well compact,
> My mind as generous, and my shape as true,
> As honest madam's issue? Why brand they us
> With base? with baseness? bastardy? base? base?
> Who in the lusty stealth of nature take
> More composition and fierce quality
> Than doth, within a dull, stale, tired bed
> Go to the creating a whole tribe of fops
> Got 'tween sleep and wake?" Act I. Scene 2.

"Hercules, Romulus, Alexander (by Olympia's confession), Themistocles, Jugurtha, King Arthur, William the Conqueror, Homer, Demosthenes, P. Lumbard, P. Comestor, Bartholus, Adrian the fourth Pope, &c. were bastards; and in almost every kingdom the most ancient families have been at first princes' bastards, the worthiest captains, best wits, greatest scholars, bravest spirits in all our annals, have been base. Cardan, in his subtleties, gives a reason, &c.—Corpore sunt et animo fortiores spurii, plerumque ab amoris vehementiam, &c."* Were this explanation satisfactory, the first fruits of wedded love would still generally be on an equality with illegimate offspring. If a greater proportion of illegitimate than of legitimate persons have really rendered themselves illustrious, their superior energy may be attributed to the strength of their parents' constitutions, it not being likely that the weak and delicate so frequently become the prey of unlawful passions as the vigorous, and to the necessity in which such individuals usually find themselves to rely upon their own exertions.

The vulgar are satisfied that mental impressions made upon the mother may affect the offspring. If I profess the same opinion, some will no longer wonder at my being a Christian, nor others at my being an admirer of Gall and Spurzheim. Credulous, however, as I may seem, I do confess that so many extraordinary coincidences, both in the human and the brute subject, have come to my knowledge, that I dare not affirm the common belief to be altogether unfounded. That neither all nor most mal-formations can be thus explained, that pregnant women are frequently alarmed without such consequences even when most dreaded, and that highly ridiculous resemblances are fancied to preceding longings and alarms that were forgotten or may be well suspected to have never existed, is incontestable. But, in other matters, when a circumstance may proceed from many causes, we do not universally reject any one because it is frequently alleged without reason. To argue from the non-appearance of

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* Burton, *Anatomy of Melancholy.* Vol. ii. p. 16 sq.

nerves in the umbilical chord, would be unworthy of the pretension to an enlarged acquaintance with physiology. How those who believe the Divine authority of every part of their Bible can reconcile the success of Jacob's stratagem* (so anciently was the remark common) with their contempt for the vulgar belief, they best can tell.

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* "And Jacob took him rods of green poplar, and of the hazel and chesnut tree; and pilled white strakes in them, and made the white appear which was in the rods. And he set the rods which he had pilled before the flocks in the gutters in the watering troughs, when the flocks came to drink, that they should conceive when they came to drink. And the flocks conceived before the rods, and brought forth cattle ringstraked, speckled, and spotted." *Genesis*. xxx.

SECT. XLI.

OF LABOUR AND ITS SEQUELÆ.

594. The fœtus, formed by the powers already described, and having reached the period of full maturity, has to come into the world by means of *labour*.*

595. This critical *period* occurs naturally (and physiology treats solely of natural occurrences) at the end of the tenth lunar month from conception, i. e. about the 39th or 40th week.

596. At that time, the pregnant woman is impelled to bring forth by an absolute necessity, less under the influence of the will than any other voluntary function (287).

597. Physiologists have differed in their explanations of the *causes* of so determinate and sudden an event. After all, the *exciting* cause of labour must be ascribed to an established law of nature, hitherto equally inexplicable as so many other *periodical* phenomena; v. c. the metamorphosis of insects, the stages of exanthematic fevers, crises, &c. &c. nor has the mature ovum been inaptly compared, *cæteris paribus,* to fruit, which, when ripe, falls almost spontaneously to the ground, from the constriction of those vessels which previously conveyed its nourishment. And in fact it has been remarked that the human placenta, at

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* J. J. Römer, *Partus naturalis brevis expositio.* Gotting. 1786. 8vo.

the approach of labour, is contracted, and, as it were, prepared for its separation from the uterus.

What is usually urged respecting the utmost expansion of the uterus, and other similar excitements to labour, is refuted by many circumstances, and, among the rest, by the numerous examples of extra-uterine, whether tubal or ovarian, conceptions, in which, at the expiration of ten months from impregnation, the uterus, notwithstanding its vacuity, is seized with the customary, though indeed fruitless, pains.*

598. Besides this exciting cause, other very powerful *efficient* causes are requisite, as must be manifest from the relation of the ovum to the uterus.

We are persuaded that the *proximate* and primary cause, is solely the *vita propria* of the uterus. (42, 547.)

Among the *remote*, the most important appears to be the respiratory effort excited principally by the great connection† of the intercostal nerve with the rest of the nervous system.

599. We formerly noticed (582) that, in the latter periods of pregnancy, the uterus somewhat subsided, by which circumstance the form of the abdomen is a little changed and the inconveniences induced during advanced pregnancy in the function of respiration are relieved. At the same time, the vaginal mucus (543) is secreted more abundantly, the vagina itself is relaxed, the columns of rugæ are almost obliterated, and the labia pudendi swell; finally, near the approach of labour, the os uteri gradually dilates into a circular opening.

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* I have recorded a remarkable instance of this kind in the *Comment. Soc. Scient. Gottingens.* Vol. viii.

† v. Camper, *Demonst. anat. pathol.* L. ii. p. 9.

600. The *phenomena* of labour generally observe a regular order of commencement and cessation,* whence accoucheurs have divided them into *stages*, of which the moderns enumerate four, although they define them variously.

601. In the *first*, the true pains occur, peculiar in their nature, proceeding from the loins downwards in the direction of the uterus (recurring, at intervals, indeed, during the whole of labour, with various degrees of violence and frequency), mild in the beginning, at which time they are called *warning* and the os uteri begins evidently to dilate. The abdomen now falls still more, the urine is urgent, and abundance of mucus flows from the soft and tumid genitals.

602. In the *second*, the pains, increasing, are called *preparing*, and, by the compressing effect of the respiratory organs, a strong inspiration, &c. a segment of the lower part of the membranes of the ovum is protruded through the uterine orifice into the vagina.

603. In the *third*, the pains, becoming more excruciating, are called *labour pains*, and act with still more violence upon the uterus, which is driven downwards and compressed against the fœtus, so that the protruded segment of membranes becomes extremely tense, is burst asunder, and the greater part of the liquor amnii escapes.

604. Finally, in the *fourth* and last stage, the pains, becoming dreadfully violent and *agitating*,† are accom-

* v. Smellie, *Set of anatomical tables.* Tab. xi.—xv.

† Although, even among my own countrywomen, the symptoms described under these four stages, vary greatly in violence and proportionate duration; nevertheless, however naturally they take place, they universally, (excepting

panied by great exertions of the woman herself; almost always too by shivering, shrieking, tremor of the knees, &c. The head of the child, now on the verge of birth, penetrates, and the face first appears, the vertex usually remaining under the arch of the pubes and the rest of the head in the mean time being farther propelled and revolving around the impacted vertex as around an axis. Thus the child comes into the world, in the midst of a red discharge, consisting of a second portion of the liquor amnii mixed with blood.

605. Soon after the expulsion of the child, the *after-labour* commences, attended by a painful though much less violent exertion, and followed by another hemorrhage from that part of the cavity of the womb * to which the placenta had adhered by means of the decidua crassa.†

606. Immediately that both burthens are expelled, the uterus begins gradually to contract, until it acquires its original form and very nearly its original dimensions.

607. For about a week after labour, the *lochia* are

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some extremely rare cases) so far surpass, even under the most favourable circumstances, the pains experienced by domestic brutes in their labours, that I trust no one who has frequently witnessed labours in both, will seriously doubt the immense difference between the two in this respect.

* B. S. Albinus, *Tab. uter. gravid.* vij.

Wm. Hunter, *Anat. of the gravid uterus.* Tab. x. fig. 3.

† Nic. Massam and all siuce his time denominate this portion of the womb, during or shortly after pregnancy, *the cotyledons*, from the analogous appearance observable in the gravid uterus of sheep or goats, in which similar cavities (*acetabula*) exist, receiving what are called the glandular corpuscles of the chorion that correspond with the fœtal portion of the human placenta.

Whatever was hollow, like an acetabulum, was called κοτύλη by the ancients. Vide J. Cammerarii *Comm. utriusque linguæ.* p. 256. 384.

discharged, for the most part very similar to the catamenia, but rather more copious, especially if the mother does not suckle her offspring. About the sixth day their red colour becomes fainter, and afterwards changes to white. At the same time the uterus is liberated from the remaining shreds of the decidua, and, having thus completed the function of pregnancy, is again ready for menstruation or conception.

SECT. XLII.

OF THE MILK.

608. The *breasts,* most sacred fountains, and, as Gellius Favorinus the philosopher elegantly calls them, the rearers (*educatores*) of the human race, are intimately connected with the uterus in various ways. The functions of neither can properly be said to exist durring infancy; at puberty, both begin to flourish,—when the catamenia appear, the breasts assume some degree of plumpness; from that period they undergo either simultaneous changes,—the breasts beginning to swell and secrete milk during the pregnancy of the womb, or alternate changes,—the catamenia ceasing while the child is suckled, or the lochia becoming copious if the child is not suckled, and s. p. Finally, when age creeps on, the function of each absolutely ceases,—when the catamenia disappear, both the uterus and the breasts become equally inert. I omit pathological phenomena; v. c. those which occur in irregular menstruation, leucorrhœa, after extirpation of the ovaria, and in other morbid affections.

609. If this intimate connection is kept in view, we shall not be astonished that nearly every description of sympathy formerly mentioned (56) exists between these organs of the female thorax and abdomen.*

* J. Anemaet, *De mirabili quæ mammas inter et uterum intercedit sympathia.* LB. 1784. 4to.

610. The influence of the anastomatic sympathy between the internal mammary and epigastric artery,* although formerly overrated,† is evinced by the change which the latter experiences in its diameter during pregnancy and suckling.

611. Both the uterus and mammæ appear to have a kind of affinity for the chyle, observable in many diseases and nearly always in new-born children.

612. The *breast* of women,‡ belonging to the most characteristic marks of the human female both by its form during the flower of age and by the longer continuance of this form after the period of suckling than occurs in any other female animal, is composed of a placentiform series of conglomerate glands, divided by numerous furrows into larger lobes, and buried in a mass of fat; the anterior part swells out particularly with a firmer description of fat over which the skin is exceedingly thin.

613. Each of these lobes is composed of still smaller lobes, and these of acini, as they are termed, to which the extreme radicles § of the *lactiferous ducts* adhere, deriving a chylous fluid from the ultimate twigs of the internal mammary arteries.

614. These radicles, gradually uniting,|| form large trunks, corresponding in number with the lobes,—about

* Eustachius, Tab. xxvii. fig. 12.

Haller, *Icon. anat.* fasc. vi. tab. i.

† As G. R. Boehmer properly remarks, *De consensu uteri cum mammis causa lactis dubia.* Lips. 1750. 4to.

‡ A. B. Kölpin, *De structura mammarum.* Griphisw. 1765. 4to.

Athan. Joannidis, *Physiologiæ mammarum muliebrium specimen.* Hal. 1801. 4to.

§ v. C. A. Cavolo's two plates at the end of Santorini's posthumous tables.

|| v. Mich. Girardi, Tab. i. annexed to the same plates of Santorini.

fifteen in each breast. These are every where dilated into large sinuses, but have no true anastomosis with each other.*

615. These trunks terminate in very delicate excretory canals, that are collected, towards the centre, by means of cellular substance, into the *nipple*,† which, supplied with extremely fine blood-vessels and nerves, is capable of a curious erection on the approach of certain external stimuli.

616. The nipple is surrounded by the *areola*,‡ which, as well as the nipple, is remarkable for the colour § of the reticulum under the cuticle, || and contains sebaceous follicles.**

617. The secretion of the breast is the *milk*, well known in colour, watery, somewhat fatty, rather sweet, bland, resembling in all respects the milk of domestic animals, but subject to infinitely greater varieties in the proportion of its constituent parts, far more difficult of coagulation from the great quantity of salt which it contains, and affording no trace of volatile alkali.††

618. When coagulated by means of alcohol, it dis-

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* J. Gottl. Walter, *Observ. Anat.* p. 33 sq.

† Santorini, *Tab. posth.* viii.

‡ Ruysch, *Thes.* i. tab. iv. fig. 4.

§ In pregnant women, especially during the first pregnancy, the nipples are usually yellow. In the Samojede females, even when virgins, Klingstaedt asserts that they are quite black. *Mém. sur les Samojedes et les Lappons.* p. 44.

|| B. S. Albinus, *Annotat. Acad.* L. iii. tab. iv. fig. 3.

** Morgagni, *Advers. Anat.* i. tab. iv. fig. 2.

†† Fl. J. Voltelen (Præs. Hahn), *De lacte humano observationes chemicæ.* LB. 1775, 4to.

Parmentier and Deyeux, *Précis d'Expériences et observations sur les différentes espèces du lait.* Strasburg. 1798. 8vo. Thenard, *Annales de Chimie.* T. lix. p. 262.

covers the same elements as the milk of other animals. Besides the *aqueous* halitus which it gives off when fresh and warm, the *serum,* separating from the *caseous* part, contains sugar of milk* and acetic acid mixed with phosphate of lime and of magnesia and with oil and mucus. The butyraceous *cream* is said to consist of globules of various and inconstant size, their diameter ranging between $\frac{1}{200}$ and $\frac{1}{600}$ of a line.†(A)

619. The analogy between chyle and blood, and between both these fluids and milk,‡ renders it probable that the milk is a kind of reproduced chyle, again separated from the blood before its complete assimilation. This idea is strengthened by the frequent existence in the milk of the particular qualities of food previously taken,§ and by the chylous appearance of the watery milk secreted during pregnancy and immediately after labour.‖

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* Marc. L. Williamoz, *De sale lactis essentiali.* LB. 1756. 4to.

† Senac, *Tr. du cœur.* Vol. ii. p. 276. ed. 2.

Fr. v. P. Gruithuisen, *Untersuch. über den Unterschied zwischen Eiter und Schleim durch das Microscop.* Munich. 1809. 4to. p. 16. fig. 15.

‡ Compare J. Theod. Van de Kasteele, *Diss. de analogia inter lac et sanguinem.* LB. 1780. 4to. and Alex. Wilson on the analogy between milk and chyle, *Observations relative to the influence of the climate.* p. 97 sqq.

§ v. Among a host of witnesses, Kölpin in Pallas's *Neuen nordischen Beyträgen.* Vol. ii. p. 343.

‖ Many circumstances induce me to believe that the lymph of the absorbents is of much importance in the secretion of milk.

For instance, the swelling of the subaxillary glands almost always observable during the first months of pregnancy.

But especially the remarkable fact,—that in advanced pregnancy, when, from the womb compressing on account of its size the large and numerous lumbar plexuses of lymphatics, the legs have swollen, this œdematous tumour so completely disappears immediately after labour that the calves of the legs hang almost flaccid from the lymph finding no impediment in the lumbar plexuses

620. The reason why this bland nourishment of the fœtus becomes more thick and rich by continued suckling, is probably the abundance of lymphatics in the breasts. Those vessels continually absorb more of the serous part of the milk, in proportion as its secretion is more copious and of longer standing, and, by again pouring this part into the mass of blood, promote the secretion (477): after weaning they take up the remaining milk and mix it with the blood.

621. The milk is secreted in greatest quantity immediately after delivery; and, if the infant sucks, amounts to one or two pounds every twenty-four hours, until the menses, which usually cease during suckling, (556) return.

Occasionally virgins, and new-born infants of either sex, nay even men,* as well as the adult males of other mammalia,† have been known to furnish milk.

622. The abundance of milk excites its *excretion*, and even causes it to flow spontaneously: but pressure, or the suction of the child, completes its discharge. (B)

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and rushing upwards, and a more copious secretion of milk instantly ensues upon the passage of the lymph.

The momentary thirst (330) experienced on applying the child to the breast, from the absorption of fluid in the fauces, may be also mentioned.

* This is asserted to be very common in Russia. *Comment. Acad. sc. Petropolit.* Vol. iii. p. 278 sq.

† I have spoken of this at large in the *Hannoverisch. Magazin.* 1787. p. 753 sq.

NOTES.

(A) The lower portion of cows' milk that had stood some days was found by Berzelius * to have a specific gravity of 1.033. and to contain

Water - - - - - - -	928.75
Cheese with a trace of butter - - -	28.00
Sugar of milk - - - - -	35.00
Muriate of potash - - - - -	1.70
Phosphate of potash - - - -	0.25
Lactic acid, acetate of potash, with a trace of lactate of iron - - - - -	6.00
Earthy phosphates - - - - -	0.30
	1000.00

The supernatant cream contained

Butter - - - - - - -	4. 5
Cheese - - - - - - -	3. 5
Whey - - - - - - -	92. 0

(B) It may be worth while here to take a general view of the subject of generation.

Life never occurs spontaneously in matter, but is always propagated from an organised system already endowed with it. Such, at least, appears to be the inevitable conclusion from the facts within our observation. No instance has been known of a plant or animal of any species, whose mode of multiplication may be always easily examined, springing up spontaneously; and although in many other cases the origin often cannot be discovered, yet surely our inability to discover the mode of propagation does not justify us in denying the existence of it; but, the general analogy, the discovery of the modes in which many species propagate which were formerly adduced as instances of spontaneous

* *Medico-Chirurgical Transactions.* V. iii.

generation, and the occasionally manifest source of the difficulties which obstruct our enquiries, lead necessarily to the belief, not of the unreality of the fact, but of our deficient penetration.*

The simplest mode of increase is by the detachment and independent existence of a portion of a system. In this way trees,† polypes, some worms, and many animalcules, ‡ multiply.

Next comes the formation of the rudiments of a perfectly new being by the system of another. Thus we have the seed of vegetables, the ova and fœtus of animals. This occurs by means of two matters, which in some examples are furnished by the same, and in others, by different, systems. The vegetable kingdom affords innumerable instances of the former, the acephalous mollusca and the echinus are examples in the animal kingdom.§ Both the vegetable and animal kingdoms abound in instances of the latter. Here again there are three varieties. The fluid of the male may be applied to the ova of the female after they are discharged from her body, as in fish of the bony kind and in

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* See Cuvier's *Anatomie Comparée.*—Generation.

† Hic plantas tenero abscidens de corpore matrum
Deposuit sulcis; hic stirpes obruit arvo,
Quadrifidasque sudes et acuto robore vallos;
Silvarumque aliæ pressos propaginis arcus
Exspectant, et viva sua plantaria terra;
Nîl radicis egent aliæ; summumque putator
Haud dubitat terræ referens mandare cacumen.
Quin et caudicibus sectis (mirabile dictu)
Truditur e sicco radix oleagina ligno.

VIRGIL. *Georgica.* Lib. ii.

‡ See Spallanzani's admirable *Observations et experiences sur les Animalcules.* He found a small portion detach itself from the bodies of some, the bodies of others split longitudinally, of others transversely, of others both longitudinally and transversely into four parts, and the new animalcules soon acquired the size of the parent and experienced the same changes in their turn.

§ It is singular that some hermaphrodites do not impregnate themselves, but mutually impregnate and are impregnated by others; such are the gasteropodous mollusca and many worms.

cephalopodous mollusca; while being discharged, as in the frog and toad; or it may be conveyed to the female system, and this either without the contact of the male, as in vegetables, where the wind, insects, &c. convey it, or by means of copulation, as in the mammalia,* birds, most reptiles, and some fish. In the mammalia, one copulation is sufficient for only one conception; among poultry its effects are so extensive, that a hen will lay a long succession of fruitful eggs after one intercourse with the cock; in the aphis and some monoculi, it is sufficient for the impregnation of several generations.

The ovum after its formation may be nourished by a fluid enclosed within the same case, and is then hatched out of the body by the common temperature, as in insects, or by that of the parent, as in birds, or hatched within the body of the mother, as in serpents; or it may be nourished by a substance shed around it in the womb, as in the kangaroo, or by means of an attachment of some of its vessels to the maternal system, as in

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* Ladies were treated formerly with more politeness than at present. An accidental pregnancy was frequently attributed to the warmth of imagination, the influence of demons, and many other circumstances supposed equally powerful as the deed of kind. In Venette's *Tableau de l'Amour conjugal*, and in Bartholin's works, may be seen an *Arrêt Notable de la cour du Parlement de Grenoble*, which, upon the attestation of many *matrones* and *sages femmes* and *docteurs* of the University of Montpellier that women often fall pregnant spontaneously, declares a lady who had brought forth a son although her husband had been absent four years, to be a woman of worth and honour, and the child to be the legitimate heir of Monsieur the husband.

The ancients believed that mares were sometimes impregnated by the wind,—ἐξανεμοῦσθαι.

Vere magis, quia vere calor redit ossibus, illæ
Ore omnes versæ in Zephyrum stant rupibus altis,
Exceptantque levis auras; et sæpe sine ullis
Conjugiis vento gravidæ (mirabile dictu)
Saxa per et scopulos et depressas convallis
Diffugiunt.

VIRGIL. *Georg.* Lib. iii.

the mammalia in general:—some animals being thus oviparous, others ovoviviparous, and others viviparous.

The mode of nourishment after birth is various. Some are able, without any peculiar arrangement, immediately to support themselves; for the wisdom of the Creator ordains the delivery of each species of animals at that season of the year when every thing is in the most favourable state for administering to the necessities of the offspring. Some, many insects for example, are born in the midst of food, the parent having instinctively deposited the egg in nutrient matter either found in mass or carefully collected by her. Others have food collected daily by the parents. Some, as all the dove kind, are fed by a substance secreted from the crops of both parents;* others by a fluid secreted by peculiar glands belonging to the female only.† The instinct which leads the parent carefully to tend the offspring, ceases at the period when the system of the offspring is sufficiently advanced to supply its own exigencies, and the parent does not breed again till this is the case.

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* Hunter, *On a secretion in the crops of breeding pigeons for the nourishment of their young*, in his *Observations on certain parts, &c.* p. 235.

† Mr. Hunter satisfied himself experimentally of the truth of the common assertion,—that the she-ass gives milk no longer than the impression of the foal is upon her mind. The skin of her foal thrown over the back of another, and frequently brought near her, is sufficient. *Journal of the Royal Institution.* No. 2.

SECT. XLIII.

OF THE DIFFERENCES IN THE SYSTEM BEFORE AND AFTER BIRTH.*

623. FROM what has been said relatively to the functions of the fœtus still contained within its mother and immersed as it were in a warm bath, there must evidently be a considerable difference between its animal functions and those of the child that is born and capable of exerting its will. The chief points of difference we shall distinctly enumerate.

624. To begin with the blood and its motion, this fluid is remarkable both for being of a darker red, incapable of becoming florid on the contact of atmospheric air, and for coagulating less readily and perfectly than after birth.† Its course too is very different in the fœtus whose circulation is connected with the placenta and who has never breathed, from its course

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* On the subject of this section consult among numerous others, Trew, *De differ. quibusdam inter hominem natum et nascendum intercedentibus.* Norimb. 1736. 4to.

Andr. and Fr. Roesslein (brothers), *De differentiis inter fœtum et adultum.* Ibid. 1783. 4to.

Ferd. G. Danz, *Zergliederungskunde des ungebohrnen Kindes mit Anmerk.* von. S. Th. Soemmerring. Frankfort. 1792. 2 vols. 8vo.

Also Theod. Hoogeveen, *De fœtus humani morbis.* LB. 1784. 8vo. p. 28 sq.

Fr. Aug. Walter, *Annotat. academ.* already quoted. p. 44 sq.

And J. Dan Herholdt, *De vita imprimis fœtus humani.* Havn. 1802. 8vo. p. 61 sq.

† Fourcroy, *Annales de Chimie.* T. vii. page 162 sq.

after the cessation of this connection with the mother and after respiration has taken place.*

625. First, the umbilical vein, coming from the placenta and penetrating the ring called umbilical, runs to the liver, and pours its blood into the sinus of the vena portæ, the branches of which remarkable vein distribute one portion through the liver, while the *ductus venosus* ARANTII † conveys the rest directly to the inferior vena cava.

Both canals,—the end of the umbilical vein contained in the abdomen of the fœtus, and the venous duct, become closed after the division of the chord, and the former is converted into the round ligament of the liver.

626. The blood, arriving at the right side of the heart from the inferior cava, is in a great measure prevented from passing through the lungs, and is derived into the left or posterior auricle of the heart, by means of the Eustachian valve and the foramen ovale.

627. For, in the fœtus, over the opening of the inferior cava, there is extended a lunated *valve*,‡ termed, from its discoverer,§ Eustachian, which usually dis-

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* Herm. Bernard, *De eo quo differt circuitus sanguinis fœtus ab illo hominis nati.* Reprinted in Overkamp's collection. T. i.

Jos. Wenc. Czikanek, *De actuosa hominis nascituri vita s. circulat. fœtus ab hominis nati diversitate.* Reprinted in Wasserberg's collection. T. iv.

Sabatier at the end of his *Tr. Complet. d'Anat.* Vol. iii. p. 386 sq. 1781; and in the *Mémoires Mathemat. et Physiques de l'Institut.* T. iii. p. 337 sq.

But especially J. Fr. Lobstein, *Magasin Encyclopédique.* 1803. T. iii. Vol. li. p. 28 sq.

† Arantius, *De humano fœtu libellus.* p. 97.

Compare B. S. Albinus, *Explicatio tabular. Eustachii.* p. 164 sq.

‡ Haller, *De valvula Eustachii.* Gotting. 1738. 4to.

§ Eustachius, *De vena sine pari.* p. 289. Opuscula. tab. viii. fig. 6. tab. xvi. fig. 3.

appears as adolescence proceeds, but, in the fœtus, appears to direct* the stream of blood coming from the abdomen towards an opening, immediately to be mentioned, existing in the septum of the auricles.

628. This opening is denominated the *foramen ovale*,† and is the cause that certainly the greatest part of the blood which streams from the inferior cava is poured into the left auricle during the diastole of the auricles. A falciform‡ valve, placed over the foramen, prevents its return, and appears likewise to preclude its course into the left auricle during the systole of the auricles. By means of this valve, the foramen generally becomes closed in early infancy in proportion as the corresponding Eustachian valve decreases and more or less completely disappears.§

629. The blood which enters the right auricle and ventricle principally proceeds from the superior cava, and flows but in a very small quantity into the lungs, while, from the right ventricle, which, in the fœtus, is particularly thick and strong for this purpose, it pursues its course directly to the arch of the aorta, by means of the *ductus arteriosus*,|| which is in a manner the chief branch of the pulmonary artery. A few weeks

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* J. F. Lobstein, *De valvula Eustachii.* Arg. 1771. 4to.

† Haller, *De foramine ovali et Eustachii valvula.* Gotting. 1748. fol. c. f. ae. and much more copiously in his *Opera minora.* T. i. p. 33 sqq.

‡ For an account of the opinion of C. Fr. Wolff, who regards the foramen ovale as another mouth of the inferior cava, opening into the left auricle in the same manner as the mouth commonly known opens into the right, See *Nov. Comment. Acad. Scient. Petropol.* T. xx. 1775.

§ H. Palm. Leveling, *De valvula Eustachii et foramine ovali.* Anglipol. 1780. 8vo. c. f. ae.

|| B. S. Albinus, *Annot. acad.* L. ii. tab. vii. fig. 7.

after birth, this duct becomes obstructed and converted into a kind of dense ligament.

630. The blood of the aorta, being destined to return, in a great measure, to the mother, enters the *umbilical arteries* (572), which pass out on each side of the urachus at the umbilical opening, and, after birth, likewise become imperforate chords.*

631. As the function of the *lungs* scarcely exists in the fœtus, their appearance is extremely different from what it is after the commencement of respiration. They are proportionally much smaller, their colour is darker, their substance denser, consequently their specific gravity is greater, so that while recent and sound they sink in water, whereas, after birth, they, cæteris paribus, swim upon its surface.† The right lung has the peculiarity of dilating during the first inspiration rather sooner than the left.‡ The other circumstances attending the commencement of respiration were described in the section upon that function.

632. From our remarks upon the nutrition of the fœtus, it is clear that its alimentary tube and chylopoietic system must be very peculiar. Thus, v. c. in an embryo a few months old, the *large intestines* very

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* Haller, *Icones anat.* fasc. iv. tab. iii. vi.

† Here is not the proper place for explaining the conditions under which this occurs, and the cautions therefore requisite in giving an opinion, in a court of justice, founded on the *examination* of the *lungs.*

Among many other writings, the very important posthumous paper of Wm. Hunter may be consulted in the *Medical Observ. and Enquiries.* Vol. vi. p. 284 sq.

‡ Portal, *Mém. de l'Acad. des sc. de Paris.* 1769. p. 555 sq.

Metzger, *De pulmone dextro ante sinistrum respirante.* Regiom. 1783. 4to.

nearly resemble the small; but, during the latter half of pregnancy, being turgid with meconium, they really deserve the epithet by which they are commonly distinguished.

633. The *meconium* is a saburra, of a brownish green colour, formed evidently from the secreted fluids of the fœtus, and chiefly from its bile, because it is first observed at the period corresponding to the first secretion of the bile; and in monstrous cases, where the liver has been absent, no meconium, but merely a small quantity of colourless mucus, has been found in the intestines.

634. The *cæcum* is extremely different in the new born child from its future form, and continued straight from the appendix vermiformis, &c.*

635. Other similar differences we have already spoken of, and shall now pass over. Such are the *urachus* (573), the *membrana pupillaris*, (262) the *descent of the testes* in the male, (510 sq.)

Some will be treated of more properly in the next section. Others, of little moment, we shall entirely omit.

636. This is a favourable opportunity for briefly noticing some remarkable parts which are out of all proportion larger in the fœtus and appear to serve important purposes in its economy, although their true and principal design deserves still further investigation. They are usually styled glands, but their parenchyma is very different from true glandular structure, nor has any vestige of an excreting duct been hitherto dis-

* B. S. Albinus, *Annotat. Acad.* L. vi. tab. ii. fig. 7.

covered in them. They are the thyreoid, the thymus, and the supra-renal glands.*

637. The *thyreoid gland* † is fixed upon the cartilage of the same name belonging to the larynx, has two lobes, is, as it were, lunated, ‡ and full not only of blood, in which it abounds in the fœtus, but of lymphatic fluid, and becomes, as age advances, gradually less juicy. §

638. The *thymus* is a white and very tender structure, likewise bilobular, sometimes completely divided into two parts, occasionally containing a remarkable cavity, || placed under the superior part of the middle of the sternum, always ascending as far as the neck on each side,** of extremely great proportionate size in the fœtus, abounding in a milky fluid, becoming gradually absorbed in youth, and frequently disappearing altogether in old age.††

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* Vide F. Mechel, *Abhandlungen aus der menschlichen u. vergleichenden Anatomie.* Halle. 1806. 8vo. He makes it probable that these three organs contribute to the chemical functions of the nervous and hepatic systems, and thus diminish the quantity of hydrogen and carbon.

† C. Uttini, *De glandulæ thyroideæ usu*, in the *Comment. instituti Bononiens.* Vol. vii. p. 15 sq.

‡ Haller, *Icones Anat.* fasc. iii. tab. 3.

§ J. Ant. Schmidtmüller, *über die Ausfuhrungsgange der Schilddrüse.* Landshut. 1804. 8vo.

|| Aug. Louis de Hugo, *De glandulis in genere et speciatim de thymo.* Gotting. 1746. 4to. fig. 2.

Morand the younger, *Mémoires de l'Acad. des Sc. de Paris.* 1759. tab. 22—24.

Vincent Malacarne, *Memoric della Societa Italiana.* T. viii. 1799. P. i. page 239 sq.

Sam. Chr. Lucae, *Anatomische Untersuchungen der Thymus.* Frankfort. 1811. 4to.

** Haller, *Icones Anat.* l. c.

†† Hewson, *Experimental enquiries.* P. iii. passim.

639. The *supra-renal glands,* called also renes succenturiati and capsulæ atrabiliariæ, lie under the diaphragm on the upper margin of the kidneys,* from which, in the adult, they are rather more distant, being proportionally smaller. They are full of a dark fluid of a more reddish hue in the fœtus than in the adult.

NOTE.

Blumenbach has omitted here to notice one of the most striking peculiarities of the fœtus,—the very great proportionate bulk of its liver. The prodigious size of this organ arises from the distribution of four-fifths of the blood of the umbilical vein through it, and probably, in a certain degree, as some think, from the great quantity of meconium in its biliary ducts. After birth, no blood is conveyed by the umbilical vein, and the expansion of the thorax readily expresses the abundance of meconium ; hence the liver must diminish.

This peculiarity, as well as the great size of the thyreoid, thymus, and supra-renal glands, probably serves some purpose hitherto undiscovered, but an evident good effect results from it in relation to the organs of the thorax. In the fœtus the lungs are completely devoid of air, and consequently there cannot be much, if any, circulation of blood through the pulmonary artery and veins, and the liver by its magnitude, protruding the diaphragm upwards, renders the capacity of the chest correspondently small, and at the same time it contains an immense proportion of blood. After birth, the diminished size of the liver

* See Eustachius their discoverer, Tab. i. ii. iii. and tab. xii. fig. 1. 10. 12. Haller, *Icones Anat.* fasc. iii. tab. vi.
Malacarne, l. c.

allows a great increase to the capacity of the chest; not only is full inspiration allowed, and consequently a free passage to the blood of the pulmonary vessels during inspiration, as Haller remarks,* but a certain degree of permanent dilatation of the lungs is allowed (for much air remains in the lungs after every expiration), and as the liver contains, immediately after birth, so much smaller a portion of the blood of the system than before, the greatly increased supply required by the lungs is thus afforded.† See Note B. Sect. VIII.

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* *Elementa Physiologiæ.* T. 8.

† See Mr. Bryce's ingenious paper on this subject in the *Edinburgh Med. and Surg. Journal.* 1815. Jan.

SECT. XLIV.

OF THE GROWTH, STATIONARY CONDITION, AND DECREASE OF THE HUMAN SYSTEM.

640. NOTHING more remains at present than to survey at one view the natural course of the life of man, whose animal functions we have hitherto arranged in classes and examined individually, and to accompany him through his principal epochs from his birth to his grave.*

641. The *commencement of formation* appears to take place about the third week from conception (569), and genuine *blood* is first observable about the fourth, the life of the fœtus at this period being extremely faint (82) and little more than that of a vegetable; the *motion of the heart* (98) has, under fortunate circumstances, been observable at this time in the human embryo,† though long ago detected by Aristotle in the incubated egg‡ and ever since his time denominated the *punctum saliens*.

The original form of the embryo is simple, and, as it were, disguised, wonderfully different from the perfect conformation of the human frame, which deserves to

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* Vide Const. Anast. Philites, *De decremento seu de marasmo senili.* Hal. 1808. 8vo.

† Vide J. de Muralto, *Ephemerides N. C.* Dec. ii. ann. 1. p. 305.
Roume de St. Laurent, in Rozier's *Obs. et mém. s. la physique.* Juillet. 1775. p. 53.

‡ Aristotle, *Hist. Animal.* L. vi. cap. 3. Opera, Vol. ii. p. 326.

be regarded as the grandest effect of the nisus formativus, and at which it arrives by gradual changes or, if we may so speak, metamorphoses, from a more simple to a more perfect form.*

642. The *formation of human bone* † begins, if we are not deceived, in the seventh or eighth week. First of all, the osseous fluid forms its nuclei in the clavicles, ribs, vertebræ, the large cylindrical bones of the extremities, the lower jaw, and some other bones of the

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* Hence, as I have remarked in another place, (*Nova Litteraria Goettingensia*, a. 1808. p. 1386) human monsters are sometimes met with so strongly resembling the form of brutes, because the nisus formativus, having been disturbed and obstructed from some cause or other, could not reach the highest pitch of the human form, but rested at a lower point and produced a bestial shape. On the contrary, I have never once found among brutes a true example of monstrosity, which, by a bound of the nisus formativus, bore any analogy to the human figure.

For fuller information in regard to the resemblance of the very early human embryo to the larvæ of reptiles, and in some measure to the fœtuses of quadruped mammalia, consult after Harvey, *De generat. animal.* p. 184, 235 sq. London. 1651. 4to. Grew, *Cosmol. sacr.* p. 37, 47. Lister, *De humoribus.* p. 444. and others, especially Autenreith, *Observat. ad histor. embryon. facientium.* P. i. Tubing. 1797. 4to. Fr. Meckel, both *Auffätz. zur menschl. u. vergleich. anat.* p. 277 sq. and *Beyträg. zur vergleich. anat.* p. 63, and elsewhere. And Const. Anast. Philites, l. c.

† I say of *human* bone; for in the incubated chick it commences much later,—at the beginning of the *ninth* day, which corresponds with the *seventeenth week* of human pregnancy.

Observations, therefore, made on the incubated chick, must not be hastily applied to the formation of the human embryo,—an error committed by the great Haller himself, who asserted decidedly that *what he had demonstrated in regard to the incubated chick, was equally applicable to other classes of animals and to man himself.*

This opinion subsequently gained so much ground, that some physicians, who endeavoured to settle the forensic disputes respecting premature labour, deduced their arguments from this hasty comparison of the periods of incubation with those of human pregnancy. Vide v. c. Hug. Marreti, *Consultation au sujet d'un enfant, &c.* Dijon. 1768. 4to.

face, in the delicate reticulum of some flat bones of the skull,—of the frontal and occipital, but less early in the parietal. In general, the growth of the embryo, and indeed of the human being after birth, is more rapid as the age is less, and *vice versa.* (A)

643. About the middle of pregnancy, certain fluids begin to be secreted, as the *fat* (486) and *bile.* In the course of the seventh month, all the organs of the vital, natural, and animal, functions have made such progress, that, if the child happens to be born at this period, it is called, in a common acceptation of the word, *vital,* and regarded as a member of society.

644. In the fœtus, near its full growth, not only is the skin covered by a caseous matter, but delicate *hair appears upon the head,* and *little nails* become visible; the *membrana pupillaris* splits (262); the cartilaginous external ear becomes more firm and elastic; and in the male the *testes* descend. (510 sq.)

645. About the end of the tenth lunar month, the *child,* being born (595), undergoes, besides those important changes of nearly its whole economy which were formerly described at large, other alterations in its *external appearance;* v. c. the down which covered its face at birth gradually disappears, the wrinkles are obliterated, the anus becomes concealed between the swelling nates, &c.

646. By degrees the infant learns to employ its *mental faculties* of perception, attention, reminiscence, inclination, &c. whence, even in the early months, it dreams, and s. p.*

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* Consult Tiedemann, *über die Entwickelung der Seelenfähigkeiten bey Kindern,* in the *Hessisch. Beytr.* Vol. ii. P. ii. iii.

647. The organs of the *external senses* are gradually evolved and perfected, as the external ear, the internal nares, the coverings of the eyes, viz. the supra-orbital arches, the eyebrows, &c.

648. The bones of the skull unite more firmly; the *fonticuli* are by degrees filled up; and, about eight months after birth, *dentition* commences.

649. At this period the child is ready to be *weaned,* its teeth being intended to manducate solid food and not to injure the mother's breast.

650. About the end of the first year, it learns to rest upon its feet and *stand erect,*—the highest characteristic of the human body.*

651. The child, now weaned from its mother's breast and capable of using its feet, improves and acquires more voluntary power daily: another grand privilege of the human race is bestowed upon it,—the use of *speech,*—the mind beginning to pronounce, by means of the tongue, the ideas with which it is familiar.

652. The twenty milk teeth by degrees fall out about the seventh year, and a *second dentition* produces, in the course of years, thirty-two permanent teeth.

653. During infancy, *memory* is more vigorous than the other faculties of the mind, and much more powerful than at any other period in tenaciously receiving the impressions of objects: after the fifteenth year, the fire of *imagination* burns more strongly.

654. This more lively state of the imagination occurs very opportunely at *puberty,* when the body, under-

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* Ger. Vrolik (præs. Brugmans), *Diss. de homine ad statum gressumque erectum per corporis fabricam disposito.* Lugd. Bat. 1795. 8vo.

going various remarkable changes, is being gradually prepared for the exercise of the sexual functions.

655. Immediately after the period when the breasts of the adolescent girl have begun to swell, the chin of the boy is covered with down, and other phenomena of approaching puberty manifest themselves in either sex. The girl begins to menstruate (554),—an important change in the female economy, accompanied, among other circumstances, nearly always, by an increased brightness of the eyes and redness of the lips and by more evident sensible qualities of the perspiration. The boy begins to secrete genuine *semen* (527), and, at the same time, the *beard* * grows more abundantly, and the *voice* becomes extremely grave.

By the spontaneous internal voice of nature, as it were, the *sexual instinct* (71) is now for the first time excited, and man, being in the flower of his age, is capable of sexual connection.

656. The *period* of puberty cannot be exactly defined: it varies with climate and temperament,† but is generally more early in the female; so that, in our climate, girls arrive at puberty about the fifteenth year, and young men, on the contrary, about the twentieth. (B)

657. Soon after this, *growth* terminates; at various

* The fabulous report that prevails even to this day, respecting the want of beard among some American nations, I refuted by a host of witnesses in the *Gotting. Magaz.* ann. ii. P. vi. p. 418 sq. For I have adduced instances from the whole of America, both of nations who allow their beard to grow, at least, in part; and of others, who, upon indubitable authority, pluck out their beard by peculiar instruments, &c.

† I have inserted in the *Bibl. Medic.* vol. i. p. 558 sq. an account communicated to me by G. F. ab Haller, of procreation in a Swiss girl only nine years of age.

periods in different climates, to say nothing of particular individuals and families.* (C)

658. The *epiphyses* of the bones, hitherto distinct from their diaphyses, now become intimately united, and, in a manner, confounded with them.

659. At *manhood*—the longer and more excellent period of human existence, life is, with respect to the corporeal functions, at the highest pitch (82), or, in other words, these functions are performed with the greatest *vigour* and *constancy;* in regard to the mental functions, the grand prerogative of mature *judgment* is now afforded.

660. The approach of *old age* † is announced in women by the cessation of the catamenia (556), and not unfrequently by an appearance of beard upon the chin ;‡ in men, by less alacrity to copulate: in both, by a se-

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* For man has no peculiar privilege of not experiencing the effects of climate in common with other organised bodies, which are commonly known to arrive at their growth much later, cæteris paribus, in cold than in warm climates.

As to the giants of Patagonia and the dwarfs of Madagascar, mentioned by Commerson, I have reduced the exaggerated accounts of the former to a true statement, and have shewn that the latter are diseased Cretins, in my Treatise *De gen. hum. var. nativ.* p. 253, 260. ed. 3.

† J. Bern. Fischer, *Tract. de senio ejusque morbis.* Ed. 2. Erf. 1760. 8vo.

Benj. Rush, *Medical Inquiries and Observations.* Vol. ii. Philadel. 1793. 8vo. p. 295 sq.

Burc. W. Seiler, *Anatomiæ c. h. senilis specimen.* Erlang. 1799. 8vo.

Const. Anast. Philites, l. c.

‡ Vide J. Burlin, *De fœminis ex suppressione mensium barbatis.* Altorf. 1664. 4to. This remarkable phenomenon, that deserves further investigation, is analogous to a change frequently remarked in female birds, which, after ceasing to lay eggs, lose the feathers peculiar to their sex and acquire those characteristic of the male. Examples of this occur in the columba œnas, phasianus colchicus, pavo cristatus, otis tarda, pipra rupicola, anas boschas, &c.

nile * *dryness* and a gradually manifested *decrease* of vital energy.

661. Lastly, the frigid condition of *old age* is accompanied by an increasing dulness of both the external and internal senses, a necessity for longer sleep, and a torpor of all the functions of the system. The hairs grow white and partly fall off. The teeth gradually drop out. The neck is no longer able to give due support to the head, nor the legs to the body. Even the bones themselves—the props of the machine, in a manner waste away, &c.†

662. Thus we are conducted to the boundary of physiology,—*to death without disease,* ‡—to the senile εὐθανασία, which it is the first and last object of medicine to procure, and the *cause* of which must be self-evident from our preceding account of the animal economy. §

663. The *phenomena* of a moribund person || are coldness of the extremities, loss of brilliancy of the eyes, smallness and slowness of the pulse, which more and more frequently intermits, infrequency of respiration, which at length terminates for ever by a deep expiration.

* Joach. H. Gernet, *De siccitatis senilis effectibus.* Lips. 1753. 4to.

† I do not here repeat what I have said at large in my osteological work, p. 36 sq. upon the remarkable wasting of the bones of old men.

‡ G. Gottl. Richter, *De morte sine morbo.* Gotting. 1736. 4to.

§ J. Oosterdyk Schacht, *Tr. qua senile fatum inevitabili neccessitate ex hum. corp. mechanismo sequi demonstratur.* Ultraj. 1729. 4to.

Matt. Van Geuns, *De morte corporea et causis moriendi.* LB. 1761. 4to. reprinted in Sandifort's *Thesaurus.* vol. iii.

C. G. Ontyd, *De morte et varia moriendi ratione.* Lugd. Bat. 1791. 8vo.

Curt. Sprengel, *Instit. Medic.* T. i. Amst. 1809. 8vo. page 289 sq.

|| See the successive progress of the phenomena of death observed by the individual himself, a man of middle age, dying of dysentery, in Moritz's *magaz. zur Erfahrungs-Seelen-Kunde.* vol. i. P. i. page 63 sq.

In the dissection of other moribund mammalia the struggle of the heart may be perceived, and the right auricle and ventricle are found to live rather longer than the left. (117)

664. Death is manifested by the coldness and rigidity of the body, the flaccidity of the cornea, the open state of the anus, the lividness of the back, the depression and flatness of the loins (59 *note*), and, above all, by an odour truly cadaverous.* If these *collective marks* are present, there can scarcely be room for the complaint of Pliny,—that we ought not to feel assured of the fate of a man though we see him lie dead. † (D)

665. It is scarcely possible to define the natural *period* of life, or, as it may be termed, the more frequent and regular limit of advanced old age. ‡ But, by an accurate examination of numerous bills of mortality, I have ascertained a remarkable fact—that a pretty large proportion of Europeans reach their *eighty-fourth* year, while, on the contrary, few exceed it. (E)

666. On the whole, notwithstanding the weakness of children, the intemperance of adults, the violence of diseases, the fatality of accidents, and many other circumstances, prevent more than about perhaps seventy-eight persons out of a thousand from dying of old age,

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* Durondeau, *Nouveaux Mém. de l' Ac. de Bruxelles.* vol. i. 1788. P. i.

† C. Himly, *Commentatio* (which gained the royal prize) *mortis historiam causas et signa sistens.* Gotting. 1794. 4to.

Sol. Anschel, *Thanatologia s. in mortis naturam, causas, genera, species, et diagnosin disquisitiones.* ib. 1795. 8vo.

‡ Among other well known treatises on this subject, consult J. Gesner, *De termino vitæ.* Tigur. 1748. 4to. reprinted in the *Excerptum Italicæ et Helveticæ litterat.* 1759. T. iv.

without disease; nevertheless, if *human longevity* * be compared, cæteris paribus, with the duration of the life of any other known animal among the mammalia, we shall find that, of all the unreasonable whinings about the misery of human life, no one is more unfounded than that which we commonly hear respecting the shortness of its duration. (F)

NOTES.

(A) For a minute account of ossification I refer to Mr. Howship's papers in the *Medico-Chirurgical Transactions.*

(B) Instances continually occur in both sexes of early puberty, sometimes joined with very rapid growth. The mind however does not usually keep pace with the body, (or rather the brain with the rest of the body) nor are such individuals commonly long lived. Some males are reported to have been adult before the completion of their first year, an instance of which will presently be given in note C. One of the earliest examples of female puberty is related in the Medico-Chirurgical Transactions: † the girl began to menstruate when not three years of age, and soon after acquired large breasts, broad hips, &c. Schurig quotes numerous, and for the most part probably fabulous, instances of fecundity in either sex between the seventh and twelfth year, and one of a little couple, he nine and she eight, who managed to beget a child. ‡

The activity of the grand organs of generation,—the testes in

* Bacon de Verulamio, *Historia vitæ et mortis.* Opera. vol. ii. p. 121 sq. 128 sq. London. 1740. fol.

Chr. W. Hufeland, *Makrobiotik.* T. i. page 90. and elsewhere. Edit. 3. 1805.

† Vol. iv.

‡ *Spermatol.* p. 185 sq.

the male and the ovaria in the female, is so connected with the great changes that occur in the rest of the generative organs and in the system at large at the period of puberty, that these changes are prevented if those organs are previously removed, and are in general proportional to their evolution and activity;* and, if their removal is practised after puberty is established, the system more or less relapses into its former condition or acquires the characteristics of the opposite sex. This is well known in regard to brutes and the males of our species. We have one instance of the castration of a woman: her ovaria protruded at the groins and were so troublesome as to induce her to submit to their removal in St. Bartholomew's Hospital; she afterwards grew thinner and more muscular, her breasts shrunk away, and she ceased to menstruate.† When the ovaria have been found deficient, the signs of puberty had not appeared.‡ The absence of the uterus only is not attended by any deficiency in the general changes,§ nor does its removal destroy desire or give a woman the characters of the male. Nay, where it only is absent, there are monthly pains, and frequently most severe ones, in the pelvis, with all the attendant circumstances of menstruation, as if the discharge were taking place.||

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* I say generally, because, for instance, the greatest evolution of the testes is often accompanied either by little beard, or a small larynx, or some analogous circumstance, while the other marks of manhood are strikingly manifested; and vice versâ. A boy only six years of age, without any premature evolution of the organs of generation, is recorded to have had a beard. *Philos. Trans.* vol. 19.

† Pott, *Works.* vol. iij. p. 330. A castrator of sows and other animals in Germany is said to have been so enraged with his daughter for giving loose reins to her passions, as to have resolved to extinguish them, and to have completely succeeded by removing her ovaria.—" Ita bilis mota est, ut, aperto latere, castraret puellam, quam ab eo tempore nulla tetigit veneris cupido." Boerhaave, *Prælect. Acad.* T. vi. p. 127.

‡ *Philos. Trans.* vol. 95.

§ *Mémoires de la Société Medicale d' Emulation.* Paris. Tom. ii.

|| See a case read before the Medicinisch-Chirurgischte Gesellschaft, and to be

Mr. Hunter made an experiment respecting the removal of one ovarium only. He took two young sows in all respects similar to each other, and, after removing an ovarium from one, he admitted a boar of the same farrow to each and allowed them to breed. The perfect sow bred till she was about eight years old,—a period of almost six years, in which time she had thirteen farrows, and in all one hundred and sixty-two pigs; the other bred till she was six years old,—during a space of more than four years, and in that time she had eight farrows and in all seventy-six pigs. Thus it would appear that each ovarium is destined to afford a certain number only of fœtuses, and that the removal of one, although it does not influence the number of fœtuses produced by the other, causes them to be produced in a shorter time.*

(C) Not only do instances of early puberty and full growth frequently occur, but likewise of deficient and exuberant growth.

Dwarfs are generally born of the same size as other children, but after a few years suddenly cease to grow. They are said to be commonly ill-shaped, to have large heads, and to be stupid or malicious,† and old age comes upon them very early. The three foreign dwarfs lately exhibited in London, two men and one woman, had certainly large heads and flat noses, but in other respects were well made. The tallest of the three seemed a sulky creature, but the woman was very ingenious and obliging, and Simon Paap—the least of the three, appeared very amiable. He was twenty-eight inches high and twenty-six years old.

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be found in the *Lond. Med. & Physic. Journal.* 1819. p. 512 sq. where another is quoted from Theden. I believe I know a case of this kind myself, but dissection only can clear up the matter.

* *An experiment to determine the effect of extirpating one ovarium upon the number of young produced.* In his *Observations on certain parts, &c.*

† "It will not be easy to produce me an instance of any one giant or of any one dwarf perfectly sound in heart and mind, i. e. in the same degree with a thousand other individuals who are regularly constituted. Great mental weakness is the usual portion of giants, gross stupidity that of dwarfs." Lavater, *Physiognomy*.

They were not related to each other, and the relations of all were of the common size. Their countenances were those of persons more advanced. The smallest dwarf on record was only sixteen inches high, when thirty-seven years of age.*

The tallest person authentically recorded has never exceeded nine feet, according to Haller. The young man from Huntingdonshire, also lately exhibited in London, was of remarkable height. Although only seventeen years of age, he was nearly eight feet. He had a sister of great height, and many of his family were very tall. He was, as is usual, born of the ordinary size, but soon began to grow rapidly. He appeared amiable, and as acute as most youths of his age and rank.

Giants and dwarfs providentially seldom reach their fortieth year and have not very active organs of generation. As the period of growth is so short in dwarfs, and the period of childhood so short in those who reach puberty early, it is to be expected that their old age will be premature,—that their stationary period and decline will be likewise short.† Giants do not, like dwarfs, I believe, die from premature old age, but from mere exhaustion.

* Haller, *Elementa Physiologiæ*. T. 12. lib. 30.

† "In the year 1748, Mr. Dawkes, an eminent surgeon at St. Ives, near Huntingdon, published a small tract called Prodigium Wellinghamense, or an Account of a surprising Boy, who was buried at Wellingham, near Cambridge, upon whom he wrote the following epitaph. But whether it was ever engraved upon his tombstone I have not yet learned. It is in Latin, the English of which is—

'Stop, traveller, and wondering know, that here lie the remains of Thomas, son of Thomas and Margaret Hall. Before he was a year old, he arrived at puberty; and was near four feet high before he was three years old; endowed with great strength, exact symmetry of parts, and a stupendous voice; he had not quite reached his sixth year, when he died as of an advanced age.

'Here he was born, and here he gave way to fate, Sept. 3, 1747.'

"Mr. Dawkes viewed him, after he was dead, and says the corpse had the aspect of a venerable old man." *A Collection of Epitaphs and Monumental Inscriptions, Historical, Biographical, Literary, and Miscellaneous.* vol. ij. p. 140.

Hopkins Hopkins, weighing never more than 18lbs. and latterly but 12, died of pure old age at seventeen; and one of his sisters, but 12 years of age and weighing only 18lbs. at the time of his death, had all the marks of old age.*

(D) The heavenly serenity of the countenance of most fresh corpses is a very remarkable, and to me, I confess a very affecting and consolitary, circumstance. I cannot deny myself the pleasure of forcibly drawing the attention of my readers to it by quoting some inimitable lines of the mighty and unhappy Byron.

"He who hath bent him o'er the dead
Ere the first day of death is fled,
Before decay's effacing fingers
Have swept those lines where beauty lingers,
And marked the mild angelic air,
The rapture of repose that's there,
The fixed yet tender traits that streak
The languor of the placid cheek,
And but for that sad shrouded eye
That fires not—wins not—weeps not now,
And but for that chill changeless brow
Where cold obstruction's apathy
Appals the gazing mourner's heart
As if to him it could impart
The doom he dreads yet dwells upon,
Yes but for these and these alone,
Some moments, aye, one treacherous hour,
He still might doubt the tyrant's power:
So fair, so calm, so softly sealed,
The fair last look by death revealed." †

(E) Our countryman Parr married when a hundred and twenty years of age, retained his vigour till a hundred and forty, and died at a hundred and fifty-two from plethora induced by a change in his diet. Harvey, who dissected him, found no decay of any organ,‡ and, had not Parr become an inmate of the Earl

* *Gentleman's Magazine.* vol. 24, p. 191.

† *Giaour.*

‡ *Philos. Trans.* vol. iii. 1699.

of Arundel's family in London, he probably would have lived many years longer. Our other countryman Jenkins, who lived a hundred and sixty-nine years, is perhaps the greatest authentic instance of longevity since primitive times.

Longevity frequently runs in families, and is much disposed to by early rising and matrimony.*

Life is often protracted very long after the teeth have fallen out and the hair has turned gray.

Dr. Rush gives a striking illustration of the weakness of impressions made in advanced life, while those of earlier date are well remembered, in the instance of a German woman who had learned the language of the Americans when forty years old, and, though still living in America, had forgotten every word of it at eighty, but talked German as fluently as ever. Bishop Watson's father married and had a family very late, and when extremely aged would twenty times a day ask the name of the lad at college, though he would "repeat, without a blunder, hundreds of lines, out of classic anthors." †

It is a most remarkable circumstance that the system frequently makes an effort at renovation in extreme old age. I myself have known several old persons cut new teeth, and the Philosophical Transactions and other works record many similar facts,—even that of a complete third set. Dr. Rush mentions an old man in Pennsylvania who at sixty-eight lost his sight and remained perfectly blind for years, though otherwise in complete health: at eighty he regained his sight spontaneously without any visible change in the eyes, and could see as well as ever in his life at eighty-four, when the account was written.

I need scarcely observe that the height and the age of men at present are the same as they have always been. It is a common custom to magnify the past. Homer, who flourished

* See an original and beautiful *Account of the State of the Body and Mind in old Age*, in the *Med. Inquiries and Observations* (vol. ij.) of that most interesting writer Dr. Rush.

† *Anecdotes of the Life and Writings of Bishop Watson, &c.*

almost three thousand years ago, makes his heroes hurl stones in battle which

——— οὐ δύο γ' ἄνδρε φέροιεν
Οἷοι νῦν βροτοί εἰσι.*

Yet the giant who was the terror of the Israelites did not probably exceed nine feet in height, and it was to David who slew him and appeared but little more than a century later than Homer's heroes that Barzillai thus excused himself for not visiting the royal palace at Jerusalem :—" I am this day fourscore years old; and can I discern between good and evil? can thy servant taste what I eat or what I drink? can I hear any more the voice of singing men and singing women? wherefore then should thy servant be yet a burden unto my lord the king?"† Moses lived five hundred years earlier than David, and writes,— " The days of our years are threescore and ten; and if by reason of strength they be fourscore years, yet is their strength labour and sorrow: for it is soon cut off, and we fly away.‡

(F) The functions of the human machine having now been fully described, it may be useful to consider it in its relation to other animated systems and to review the chief varieties in which it appears.

Numerous authors have remarked that a gradation exists among all the objects of the universe, from the Almighty Creator, through arch-angels and angels, men, brutes, vegetables, and inanimate matter, down to nothing.

" Vast chain of being which from God began,
Natures ethereal, human, angel, man,
Beast, bird, fish, insect, what no eye can see,
No glass can reach, from infinite to thee,
From thee to nothing." §

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* *Iliad.* lib. 5.

† *II. Samuel.* xix. 35.

‡ *Psalm* 90.—ascribed to Moses by most biblical scholars.

§ Pope, *Essay on Man.* Epistle 1.

Yet this gradation, striking as it is, deserves not the epithet regular or insensible. "The highest being not infinite must be, as has been often observed, at an infinite distance below infinity." "And in this distance between finite and infinite there will be room for ever for an infinite series of indefinable existence. Between the lowest positive existence and nothing, wherever we suppose existence to cease, is another chasm infinitely deep; where there is room again for endless orders of subordinate beings, continued for ever and ever, and yet infinitely superior to non-existence." "Nor is this all. In the scale, wherever it begins or ends, are infinite vacuities. At whatever distance we suppose the next order of beings to be above man, there is room for an intermediate order of beings between them, and if for one order then for infinite orders; since every thing that admits of more or less, and consequently all the parts of that which admits them, may be infinitely divided. So that as far as we can judge, there may be room in the vacuity between any two steps of the scale, or between any two points of the cone, for infinite exertion of infinite power. †

In fact, at how vast a distance do we see the innate mental properties of man standing above those of the most sagacious brute! how immensely does the volition of the lowest animal raise it above the whole vegetable kingdom! and how deep the chasm between the vital organisation of the meanest vegetable and a mass of inanimate matter! Gradation must be admitted, but it is far from regular or insensible. Neither does it at all regard perfection of system, nor very much the degree, but chiefly the excellence and, within the limits of the visible world, the combination, of properties. Man, placed at the summit of terrestrial objects by the excellence of his mind and the combination of the common properties of matter, of those of vegetables, and of those of brutes, with those peculiar to himself, is surpassed by the dog in acuteness of smell and by the oak in

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† Dr. Johnson, *Review of a Free Enquiry into the nature and origin of evil.*

magnitude, nor can he boast of more perfection than the gnat or the thistle in their kinds.

Bodies consist of Particles endowed with certain properties without which their existence cannot be conceived, viz. extension and impenetrability; with others which proceed indeed from their existence, but are capable of being subdued by opposing energies, viz. mobility, inertness; and with others apparently neither necessary to their existence nor flowing from it, but merely superadded, for example, various attractions and repulsions, various powers of affecting animated systems.

Inanimate Bodies have no properties which are not either analogous to these or dependent upon them, are for the most part homogeneous in their composition, and disposed to be flat and angular, increase by external accretion, and contain within themselves no causes of decay.

Vegetables, in addition to the properties of inanimate matter, possess those of LIFE, viz. sensibility, (without consciousness or perception) and contractility:* their structure is beautifully organised, and their surfaces disposed to be rounded, they grow by internal deposition, and are destined in their nature for a period of increase and decay.

Animals, in addition to the properties of vegetables, enjoy MIND, the indispensable attributes of which are the powers of consciousness, perception, and volition: the two former without the latter, were, like vegetable or organic sensibility without contractility, useless; and the latter could not exist without the two former † any more than vegetable or organic contraction could occur without sensibility: nor can the existence of mind

* By the former, stimuli act upon them, and by the latter, they upon stimuli:—by the sensibility and contractility of the vessels, substances are taken up by the roots, and circulated through the system, and converted into the various parts of the vegetable. Yet this does not imply perception, consciousness, or will. The sensibility and contractility of the absorbents and secretories of our own system carry on absorption and secretion without our consciousness or volition.

† "Sense," says Hamlet to his mother, "sure you have,
Else could you not have motion." Act III. Sc. 4.

be conceived without the faculties of consciousness, perception, and volition, any more than the existence of matter without extension and impenetrability. The possession of mind by animals necessarily implies the presence of a brain for its exertion, and of a nerve or nerves for the purpose of conveying impressions to this brain and at least volitions from it to one or more voluntary muscles. A system which is not thus gifted certainly deserves not the name of animal.*

Notwithstanding the vast interval which of necessity exists between the animal and vegetable kingdoms, the lowest brutes approach as nearly as possible in organisation, and consequently in function, to vegetable simplicity. They possess merely consciousness, perception, and volition, with the appetite for food,

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* I cannot conceive an animal without consciousness, perception, and volition; nor can I conceive these in an animal without a brain, any more than the secretion of bile without a liver or something analogous. I contend not for the name, but for the thing. Zoologists indeed affirm that many internal worms and all the class of zoophytes have no nervous system. But comparative anatomy is yet imperfect, the examination of minute parts is extremely difficult, and new organs are daily discovered. Blumenbach, after remarking that, except those animals which inhabit corals and the proper zoophytes, most genera of the other orders of the Linnæan class of vermes are found to possess a distinct nervous system, adds: "Although former anatomists have expressly declared in several instances that no such parts existed." (*Comparative Anatomy*, ch. cxvi. F.) Besides, some beings have been denominated animals without any very satisfactory reason.

Where the nervous system of an animal cannot be readily detected, its presence may be inferred from motions evidently voluntary, such as retraction upon the approach of footsteps,—proving the existence of an organ of hearing, a brain, and nerves: motion in a part *directly* stimulated, as the contraction of an hydatid upon being punctured, is no proof of an animal nature, for this is common to vegetables, for instance, the leaves of the *Dionæa Muscipula*, which contract forcibly on a slight irritation. It may likewise be inferred from the presence of a stomach, because, where there is a stomach, the food is taken in, not by absorbing vessels constantly plunged in it, but by a more or less complicated and generally solitary opening regulated by volition. John Hunter contended that the stomach was the grand characteristic of the animal kingdom.

and multiply by shoots, fixed like vegetables to the spot which they inhabit. The five senses, sexual appetite, instincts, memory, judgment,* and locomotive power, with the necessary organs, are variously superadded, and endless varieties of organisation constructed, so that air and water, the crust and the surface of the earth, are all replenished with animals completely calculated for their respective habitations.†

* I see daily instances of something deserving some such name as judgment or reason in brutes. To the incredulous I offer the following anecdote in the words of Dr. Darwin. "A wasp on a gravel walk had caught a fly nearly as large as itself. Kneeling on the ground, I observed him separate the tail and the head from the body part to which the wings were attached. He then took the body part in his paws and rose about two feet from the ground with it; but a gentle breeze wafting the wings of the fly turned him round in the air and he settled again with his prey upon the gravel. I then distinctly observed him cut off with his mouth first one of the wings and then the other, after which he flew away with it unmolested with the wind." *Zoonomia:* Instinct.—The works of the two Hubers *Sur les abeilles* and *Sur les mœurs des fourmis indigénes* furnish an abundance of most interesting instances of reason in those insects.

† An error has been committed not only in representing the gradation regular, but in supposing every species of animal to constitute a distinct step in the gradation. "The whole chasm in nature," says Addison, (*Spectator. No.* 519,) "from a plant to a man, is filled up with divers kinds of creatures, rising one above another, by such a gentle and easy ascent, that the little transitions and deviations from one species to another are almost insensible." "All quite down from us," says Locke, (*Essay on the Human Understanding.* B. III. c. 6.) "the descent is by easy steps, and a continued series of things, that in each remove differ very little one from the other. There are fishes that have wings, and are not strangers to the airy region; and there are some birds, that are inhabitants of the water; whose blood is cold as fishes, and their flesh so like in taste that the scrupulous are allowed them on fish days. There are animals so near of kin both to birds and beasts, that they are in the middle between both: amphibious animals link the terrestrial and aquatic together, seals live at land and at sea, and porpoises have the warm blood and entrails of a hog; not to mention what is confidently reported of mermaids or sea-men." "In respect of our intellectual and moral principles," remarks Mr. Dugald Stewart, (*Outlines of Moral Philosophy.* par. 109.) "our nature does not admit of comparison with that of any other inhabitant of this globe:

Man, besides the common properties of animals, has others which raise him to an immense superiority. His mind is endowed with powers of the highest order which brutes have not, and his body, being, like the bodies of all animals, constituted in harmony with the mind that the powers of the latter may have effect, differs necessarily in many points of construction from the body of every brute. Well might Shakspeare exclaim, "What a piece of work is man! How noble in reason! how infinite in faculties! in form and moving how express and admirable! in action how like an angel! in apprehension how like a god! the beauty of the world! the paragon of animals!"*

The orang-outangs approach the nearest of all brutes to the human subject. Possessing expression of countenance, elevation of forehead, and less projection of the lower part of the face than other brutes, anterior extremities that are really arms and hands, and teeth of the same number and pretty much of the same figure as our own; curious, imitative, covetous, social; said by some to place sentinels and dispose themselves in a train for the propagation of alarm, to seem now and then to laugh and weep,† to walk a little occasionally erect, to defend themselves

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the difference between our constitution and theirs, being a difference, not in degree, but in kind. Perhaps this is the single instance, in which that regular gradation which we, every where else, observe in the universe, fails entirely."

Now the various kinds of animals do certainly run into each other; no two are so different but that discoveries are continually made of a third intermediate. *But connection is not gradation.* Many kinds, and the intermediate ones by which they are united, are all on a level in point of excellence and combination of properties, so that a single step in the gradation may comprehend a great number of kinds:—the whole vegetable kingdom forms but one step.

* *Hamlet.* Act. II. Sc. 2.

† Le Cat (*Traité de l'Existence du fluide des nerfs.* p. 35,) asserts that he had seen the jocko or chimpansé (*simia troglodytes*) both laugh and cry. The reader of taste will remember the lines in Milton's Paradise Lost (ix.),—

> "Smiles from reason flow,
> To brute denied."

The orang-outangs lately exhibited at Exeter-'Change,—the one a satyrus and with sticks and stones, to copulate face to face, to carry their young either in their arms or on their backs, and to be very lascivious in regard to our species; the orang-outangs at first sight afford, if any of the genus can afford, a little probability to the opinion of a close connection between apes and the human race. Uncivilised men, too, make a slight approach in many corporeal particulars, as we shall hereafter find, to the structure of other animals, and, since also the circumstances of their existence call into action few of the peculiar mental powers of our nature, they have been adduced in corroboration of this opinion. But *the least examination* displays differences of the greatest magnitude between the human and the brute creation.* These we shall

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the other a chimpansé, are said by their keepers to have sometimes laughed when much pleased, but never to have wept. Steller states the fact of weeping in regard to the phoca ursina; Pallas, in regard to the camel; and Humboldt, in regard to a small American monkey.

* In La Fontaine's charming fable of *Le Singe et le Dauphin*, the former during a shipwreck, near Athens, resolves to profit by his resemblance to man, for whom the dolphin was anciently said to have a great regard. In the hurry,

> Un dauphin le prit pour un homme,
> Et sur son dos le fit asseoir
> Si gravement, qu'on eût cru voir
> Le chanteur que tant on renomme.

Just before landing him, the dolphin asked whether he often saw the Piræus, to which he unfortunately replied,

> Tous les jours : il est mon ami :
> C'est une vieille connaissance.

One glance was sufficient to discover the difference between a man and a monkey.

> Le dauphin rit, tourne la tête ;
> Et, le magot considéré,
> Il s'apperçoit qu'il n'a tiré
> Du fond des eaux rien qu'une bête :
> Il l'y replonge, et va trouver
> Quelque homme à fin de le sauver.

review under two divisions, the first embracing the mental, and the second the corporeal, characteristics of mankind.

In judging of the mental faculties of mankind,* not merely those should be considered which an unfortunately situated individual may display, but those which all the race would display under favourable circumstances. A seed and a pebble may not on a shelf appear very dissimilar, but, if both are placed in the earth, the innate characteristic energies of the seed soon become conspicuous. A savage may in the same manner seem little superior to an orang-outang, but, if instruction is afforded to both, the former will gradually develope the powers of our nature in all their noble superiority, while the latter will still remain an orang-outang. The excellence of man's mind demonstrates itself by his voice and hands. Witness the infinite variety and the depth of thought expressed by means of words: witness his great reasoning powers, his ingenuity, his taste, his upright, religious, and benevolent, feelings, in his manufactories, his galleries of the fine arts, his halls of justice, his temples, and his charitable establishments. Besides the qualities common to all animals, each of which he, like every animal, possesses in a degree peculiar to himself, and some indeed in a degree very far surpassing that in which any brute possesses them, for instance, benevolence, mechanical contrivance, the sense for music and languages, and the general power of observation and inference respecting present circumstances, he appears exclusively gifted with at least feelings of religion and justice, with taste, with wit, and with the *reflecting* faculties of comparing and reasoning into causes.†

The corporeal characteristics of mankind are not less striking

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* In the external senses of at least smelling, hearing, and seeing, man is surpassed by brutes. Whether they have any sense not possessed by us I cannot pretend to say.

† Dr. Spurzheim, *System of Physiognomy*, passim.

and noble.* Among the beings beheld by Satan in Milton's Paradise,

> "Two of far nobler shape, erect and tall,
> Godlike erect, with native honour clad,
> In naked majesty seemed lords of all." †

The erect posture is natural and peculiar to man.‡ All nations walk erect, and, among those individuals who have been discovered in a wild and solitary state, there is no well authenticated instance of one whose progression was on all-fours. If we attempt this mode of progression, we move either on the knees or the points of the toes, throwing the legs obliquely back to a considerable distance; we find ourselves insecure and uneasy; our eyes instead of looking forwards are directed to the ground;

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* Consult Blumenbach, *De Generis Humani Varietate Nativa.* Sect. i. De hominis a cæteris animalibus differentia.

† *Paradise Lost.* Book iv. 288.

‡ There is little necessity in the present day to attempt the refutation of the ridiculous opinion that man is destined to walk on all-fours. But I do so for the purpose of displaying many peculiarities of our structure.

It is almost incredible that a thinking man could have entertained it for a moment, any more than the idea of our naturally having tails. Yet this is the fact; and, in exquisite ridicule of such philosophers, Butler makes Hudibras, after proving to his mistress by his beard that he is no gelding, fruitlessly urge his erect posture in proof that he is not a horse.

> "Next it appears I am no horse,
> That I can argue and discourse,
> Have but two legs, and ne'er a tail—
> Quoth she, That nothing will avail;
> For some philosophers of late here
> Write, men have four legs by nature,
> And that 'tis custom makes them go,
> Erroneously upon but two.
> As 'twas in Germany made a good
> B' a boy that lost himself in a wood,
> And growing t' a man was wont
> With wolves upon all-four to hunt."

Hudibras. Part ii. Canto i.

and the openings of the nostrils are no longer at the lower part of the nose,—in a situation to receive ascending odorous particles, but lie behind it. Our inferior extremities, being of much greater length, in proportion to the others and to the trunk, than the posterior of brutes with four extremities, even in children in whom the proportion is less, are evidently not intended to coincide with them in movement; they are much stronger than the arms, obviously for the purpose of great support: the presence of calves, which are found in man alone, shews that the legs are to support and move the whole machine; the thigh bones are in the same line with the trunk, in quadrupeds they form an angle, frequently an acute one; the bones of the tarsus become hard and perfect sooner than those of the carpus, because strength of leg is required for standing and walking sooner than strength of arm and hand for labour; the great toe is of the highest importance to the erect posture, and bestowed exclusively on mankind; the os calcis is very large, particularly at its posterior projection, for the insertion of the strong muscles of the calf, and lies at right angles with the leg; we alone can rest fully upon it, and in fact upon the whole of the tarsus, metatarsus, and toes. The superior extremities do not lie under the trunk as they would if destined for its support, but on its sides, capable of motion towards objects in every direction; the fore-arm extends itself outwards, not forwards, as in quadrupeds, where it is an organ of progression; the hand is fixed not at right angles with the arm, as an instrument of support, but in the same line, and cannot be extended to a right angle without painfully stretching the flexor tendons; the superior extremity is calculated in the erect posture for seizing and handling objects, by the freedom of its motions, by the great length of the fingers above that of the toes, and by the existence of the thumb, which, standing at a distance from the fingers and bending towards them, acts as an opponent, while the great toe is, like the rest, too short for apprehension, stands in the same line with them, and moves in the same direction: were our hands employed in the horizontal posture, they would be lost to us as grand instruments in the exercise of our mental superiority. Quadrupeds have a strong ligament at the back of the neck to sustain the head; in us there is no such thing, and our extensor muscles at the back of the neck are comparatively very weak.* They have the thorax deep and narrow, that the anterior extremities may lie near together and give more support; the sternum too is longer, and the ribs extend considerably towards the pelvis to maintain the incumbent viscera; our thorax is broad from side to side, that the arms being thrown to a distance may have greater extent of motion, and narrow from the sternum to the spine; and the abdominal viscera, pressing towards the pelvis rather than towards the surface of the abdomen in the erect attitude, do not here require an osseous support. The pelvis is beautifully adapted in us for supporting the bowels in the erect posture; it is extremely expanded, and the sacrum and os coccygis bend forwards below: in brutes it does not merit the name of pelvis; for, not having to support the abdominal contents, it is narrow, and the sacrum inclines but little to the pubes. The nates, besides extending the pelvis upon the thigh bones in the erect state of standing or walking, allow us to rest while awake in the sitting posture, in which, the head and trunk being still erect, our organs of sense have their proper direction equally as in walking or standing: were we compelled to lie down like quadrupeds, when resting during the waking state, the different organs of the face must change their present situation to retain their present utility, no less than if we were compelled to adopt the horizontal progression; and, conversely, were their situation so changed, the provision for the sitting posture would be comparatively useless.

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* As the head is connected with the trunk farther back in brutes than in us, the small length of lever between the occipital foramen and the back of the head, and the length of the head below the foramen, require all this power; but even in us much more upholding power than we have at the back of the neck would be required for all-four progression, as the head would no longer rest upon the spine.

While some, perversely desirous of degrading their race, have attempted to remove a splendid distinction by asserting that we are constructed for all fours, others with equal perverseness and ignorance have asserted that monkeys are destined for the upright posture. The monkey tribe, it is true, maintain the erect posture less awkwardly than other brutes with four extremities, but they cannot maintain it long, and, while in it, they bend their knees and body; they are insecure and tottering, and glad to rest upon a stick; their feet, too, instead of being spread for support, are coiled up as if to grasp something. In fact their structure proves them to be neither biped nor quadruped, but four-handed, animals. They live naturally in trees, and are furnished with four hands for grasping the branches and gathering their food. Of their four hands the posterior are even the more perfect, and are in no instance destitute of a thumb, although, like the thumbs of all the quadrumana, so insignificant as to have been termed by Eustachius, "omnino ridiculus;" whereas the anterior hands of one variety (*simia paniscus*) have not this organ. The whole length of the Orang-outang, it may be mentioned, falls very much short of ours.

It was anciently supposed that man, because gifted with the highest mental endowments, possessed the largest of all brains.* But as elephants and whales surpass him in this respect, and the sagacious monkey and dog have smaller brains than the comparatively stupid ass, ox, and hog, the opinion was relinquished by the moderns, and man was said only to have the largest brain in proportion to the size of his body. But as more extensive observation proved canary and other birds, and some varieties of the monkey tribe, to have larger brains than man in proportion to the body, and several mammalia to equal him in this particular, and as rats and mice too surpass the dog, the horse, and the elephant, in the comparative bulk of their brains; this opinion

* Consult Dr. Spurzheim, l. c. on the correspondence between the mind and the proportion of the brain in several particulars.

also gave way, in its turn, to that of Soemmerring,—that man possesses the largest brain in comparison with the nerves arising from it. This has not yet been contradicted, although the comparative size of the brain to the nerves originating from it (granting that they originate from it) is not an accurate measure of the faculties, because the seal has in proportion to its nerves a larger brain than the house dog, and the porpoise than the orang-outang.

As the human brain is of such great comparative magnitude, the cranium is necessarily very large and bears a greater proportion to the face than in any other animal. In an European a vertical section of the cranium is almost four times larger than that of the face (not including the lower jaw); in the monkey it is little more than double; in most feræ, nearly equal; in the glires, solipedes, pecora, and belluæ, less. The faculties, however, do not depend upon this proportion, because men of great genius, as Leo, Montaigne, Leibnitz, Haller, and Mirabeau, had very large faces, and the sloth and seal have faces larger than the stag, horse, and ox, in proportion to the brain, and the proportion is acknowledged by Cuvier to be not at all applicable to birds. We are assisted in discovering the proportion between the cranium and face by the facial angle of Camper. He draws two straight lines, the one, horizontal, passing through the external meatus auditorius and the bottom of the nostrils, the other, more perpendicular, running from the convexity of the forehead to the most prominent part of the upper jaw. The angle which the latter,—the proper facial line, makes with the former, is greatest in the human subject, from the comparative smallness of the brain and the great developement of the mouth and nose in brutes. In the human adult this angle is about from 65° to 85°; in the orang-outang about from 55° to 65°; in some quadrupeds 20°; and in the lower classes of vertebral animals it entirely disappears.

Neither is it to be regarded as an exact measure of the understanding, for persons of great intellect may have a prominent mouth; it shows merely the projection of the forehead, while the cranium and brain may vary greatly in size in other parts; three-fourths of quadrupeds, whose crania differ extremely in other respects, have the same facial angle; great amplitude of the frontal sinuses, as in the owl and hog, without any increase of brain, may diminish it, and for this reason Cuvier draws the facial line from the internal table of the frontal bone.

In proportion as the face is elongated, the occipital foramen lies more posteriorly; in man consequently it is most forward. While in man it is nearly in the centre of the base of the cranium, and horizontal, and has even sometimes its anterior margin elevated; in most quadrupeds it is situated at the extremity of the cranium obliquely, with its posterior parts turned upwards, and is in some completely vertical. On this difference of situation, Daubenton founded his occipital angle.* He drew one line from the posterior edge of the foramen to the lower edge of the orbit, and another, in the direction of the foramen, passing between the condyles and intersecting the former. According to the angle formed, he established the similarity and diversity of crania. The information derived from it in this respect is very imperfect, because it shows the differences of the occiput merely. Blumenbach remarks that its variations are included between 80° and 90° in most quadrupeds which differ very essentially in other points.

The want of the os intermaxillare has been thought peculiar to mankind. Quadrupeds, and nearly all the ape tribe, have two bones between the superior maxillary, containing the dentes incisores when these are present, and termed ossa intermaxillaria, incisoria, or labialia. But it does not exist universally in them.†

* *Mémoires de l'Academie des Sciences de Paris.* 1764.

† In the chimpansé that lately died at Exeter Change, the statement of Tyson and Daubenton has been verified,—that this black ape has no intermaxillary bone. The red-haired variety (*Simia Satyrus*) has it, and is destitute of nails on the hind thumbs and ligamentum teres at the head of the os femoris, both which structures this chimpansé possessed. The Satyrus is therefore not so near the human subject as the Troglotydes.

Man only has a prominent chin: his lower jaw is the shortest, compared with the cranium, and its condyles differ in form, direction, and articulation, from those of any brute: (Sect. XXI. Note F.) in no brute are the teeth arranged in such a close and uniform series; the lower incisores, like the jaw in which they are fixed, are perpendicular,—a distinct characteristic of man, for in brutes they slope backwards with the jaw bone; the canine are not longer than the rest, nor insulated as in monkeys; the molares differ from those of the orang-outang and of all the genus simia by their singularly obtuse projections.

The slight hairiness of the human skin in general, although certain parts, as the pubes and axillæ, are more copiously furnished with hair than in brutes; the omnivorous structure of the alimentary canal (Sect. XXI. Note E); the curve of the vagina corresponding with the curve of the sacrum formerly mentioned, page 428) preventing woman from being, as brute females are, retromingent; the peculiar structure of the human uterus and placenta; the length of the umbilical chord and the existence of the vesicula umbilicalis until the fourth month; together with the extreme delicacy of the cellular membrane; are likewise structural peculiarities of the human race. The situation of the heart lying not upon the sternum, as in quadrupeds, but upon the diaphragm, on account of our erect position,—the basis turned not, as in them, to the spine, but to the head, and the apex to the left nipple; the absence of the allantois, of the panniculus carnosus, of the rete mirabile arteriosum, of the suspensorius oculi; and the smallness of the foramen incisivum, which is not only very large in brutes, but generally double, though not peculiarities, are striking circumstances.

Man only can live in every climate; * he is the slowest in

* The ingenious and lively author of the excellent work *On the influence of tropical climates on European constitutions* (J. Johnson, M.D.), ascribes this superiority of man over brutes to the power of our intellect in contriving means of resisting the inclemencies of situation, but Blumenbach accounts for

arriving at maturity, and, in proportion to his size, he lives the longest of all mammalia; he only procreates at every season, and, while in celibacy, experiences nocturnal emissions. None but the human female menstruates.

Man, thus distinguished from all other terrestrial beings, evidently constitutes a separate species:—Fact harmonizes with the Mosaic account of his distinct creation. For "a species comprehends all the individuals which descend from each other, as from a common parent, and those which resemble them as much as they do each other;" and no brute bears such a resemblance to man.*

He is subject, however, to great variety, so great indeed that some writers have contended that several races of men must have been originally created. We shall now examine the principal of these varieties.

THE most generally approved division of mankind is that of Blumenbach.† He makes five varieties; the Caucasian, Mongolian, Ethiopian, American, and Malay. The following are the characteristics of each.

1. THE CAUCASIAN. The skin white; the cheeks red,—almost a peculiarity of this variety; the hair of a nut brown, running on the one hand into yellow and on the other into black, soft, long, and undulating.

The head extremely symmetrical, rather globular; the forehead moderately expanded; the cheek bones narrow, not prominent, directed downwards from the Malar process of the superior maxillary bone; the alveolar edge round; the front teeth of each jaw placed perpendicularly.

The face oval and pretty straight; its parts moderatly distinct; the nose narrow and slightly aquiline, or at least its dorsum

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it, and I think justly, by the two-fold operation of our intellect (l. c. § 18. p. 54) and of the more accommodating nature of our frame (l. c. § 17.).

* Cuvier, *Discours Préliminaire aux récherches sur les ossemens Fossiles des Quadrupèdes.*

† l. c. Sect. IV.

rather prominent; the mouth small; the lips, especially the lower, gently turned out; the chin full and round:—in short, the countenance of that style which we consider the most beautiful.

This comprehends all Europeans except the Laplanders and the rest of the Finnish race; the western Asiatics as far as the Obi, the Caspian, and the Ganges; and the people of the North of Africa.

2. The Mongolian. The skin of an olive colour; the hair black, stiff, straight, and sparing.

The head almost square; the cheek bones prominent outwards; the space between the eyebrows, together with the bones of the nose, placed nearly in the same horizontal plane with the malar bones; the superciliary arches scarcely perceptible; the osseous nostrils narrow; the fossa maxillaris shallow; the alveolar edge arched obtusely forwards; the chin somewhat projecting.

The face broad and flattened and its parts consequently less distinct; the space between the eyebrows very broad as well as flat; the cheeks not only projecting outwards, but nearly globular; the aperture of the eye-lids narrow,—linear; the nose small and flat.

This comprehends the remaining Asiatics, except the Malays of the extremity of the Transgangetic peninsula; the Finnish races of the North of Europe,—Laplanders, &c.; and the Esquimaux diffused over the most northern parts of America from Bhering's Strait to the farthest habitable spot of Greenland.

3. Ethiopian. The skin black; the hair black and crisp.

The head narrow, compressed laterally; the forehead arched; the malar bones projecting forwards; the osseous nares large; the malar fossa behind the infra-orbitar foramen deep; the jaws lengthened forwards; the alveolar edge narrow, elongated, more elliptical; the upper front teeth obliquely prominent; the lower jaw large and strong; the cranium usually thick and heavy.

The face narrow and projecting at its lower part; the eyes prominent; the nose thick and confused with the projecting cheeks; the lips, especially the upper, thick; the chin somewhat receding.

The legs in many instances bowed.

This comprehends the inhabitants of Africa; with the exception of those in the northern parts, already included in the Caucasian variety.

4. The American. The skin of a copper colour; the hair black, stiff, straight, and sparing.

The forehead short; the cheek bones broad, but more arched and rounded than in the Mongolian variety, not, as in it, angular and projecting outwards; the orbits generally deep; the forehead and vertex frequently deformed by art; the cranium usually light.

The face broad, with prominent cheeks, not flattened, but with every part distinctly marked if viewed in profile; the eyes deep; the nose rather flat, but still prominent.

This comprehends all the Americans excepting the Esquimaux.

5. The Malay. The skin tawny; the hair black, soft, curled, thick, and abundant.

The head rather narrow; the forehead slightly arched; the parietal bones prominent; the cheek bones not prominent; the upper jaw rather projecting.

The face prominent at its lower part; not so narrow as in the Ethiopian variety, but the features, viewed in profile, more distinct; the nose full, broad, bottled at its point; the mouth large.

This comprehends the inhabitants of the Pacific Ocean, of the Marian, Philippine, Molucca, and Sunda, isles, and of the peninsula of Malacca.

General Remarks. The colour of the hair thus appears somewhat connected with that of the skin, and the colour of the iris is closely connected with that of the hair. Light hair is common with a white and thin skin only, and a dark thick skin is usually accompanied by black hair; if the skin happens to be variegated, the hair also is variegated; with the cream-white skin of the albino,* we find hair of a peculiar yellowish white tint; and, where the skin is marked by reddish freckles, the hair is red. When the hair is light, the iris is usually blue; when dark, it is of a brownish black; if the hair loses the light shade of infancy, the iris likewise grows darker, and when the hair turns grey in advanced life, the iris loses much of its former colour; the albino has no more colouring matter in his chorioid or iris than in his skin, and they therefore allow the redness of their blood to appear, the latter being of a pale rose colour and semi-pellucid, the former, from its greater vascularity, causing the pupil to be intensely red; those animals only whose skin is subject to varieties, vary in the colour of the iris; and if the hair and skin happen to be variegated, the iris is observed likewise variegated.†

* Albinos spring up among all races of men; and they cannot be accounted for, except when descended from albinos, for this variety of body may be hereditary no less than it is connate and irremediable. It is known to be common to some mammalia and birds, but has never been observed by Blumenbach in cold blooded animals. (l. c. § 78.) A white rabbit is an instance of an albino. The absence of the pigmentum nigrum renders the eyes extremely sensible to light, whence such persons prefer going out in the evening. In Wafer's well known and amusing account of those he found in the isthmus of Darien, he says, "They see not well in the sun, poring in the clearest day; their eyes being weak; and running with water if the sun shine towards them; so that in the day time they care not to go abroad, unless it be a cloudy dark day. Besides they are a weak people in comparison of the others, and not very fit for hunting and other laborious exercises, nor do they delight in such, but notwithstanding their being thus sluggish and dull in the day time, yet when moonshiny nights come, they are all life and activity, running abroad and into the woods, skipping about like wild bucks; and turning as fast by moonlight, even in the gloom and shade of the woods, as the other Indians by day, being as nimble as they, though not so strong and lusty." Dampier's *Voyages*.

† The hair is frequently of different shades in different parts.

John Hunter remarked that the iris in animals agrees principally with the colour of the eyelashes.

However various the colour of the hair in horses, the iris, he also observes, is always of the same. But then the hair is always of the same at birth, and the skin does not participate in its subsequent changes, being as dark in white as in black horses. In cream-coloured horses, indeed, there is an excep-

The Caucasian variety of head, nearly round, is the mean of the rest, while the Mongolian, almost square, forms one extreme, having the American intermediate, and the Ethiopian the other extreme, having the Malay intermediate, between it and the Caucasian.

The Caucasian variety of face is also the mean, while the Mongolian and American, extended laterally, form one extreme, and the Ethiopian and Malay, extended inferiorly, constitute the other. In the first of each extreme, viz. the Mongolian and Ethiopian, the features are distinct, while in the second, viz. the American and Malay, they are somewhat blended.

Although this division of mankind is well founded and extremely useful, it is liable, like every artificial division of natural objects, to many exceptions. Individuals belonging to one variety are not unfrequently observed with some of the characteristics of another; * the characteristics of two varieties are

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tion,—the iris agrees with the hair, but then the foals are originally cream coloured and the skin is cream coloured. Hunter, *On the colour of the pigmentum of the eye in different animals.* l. c. p. 247.

* "Sooty blackness is not peculiar to the Ethiopian, but is occasionally found in other varieties of men very different and remote from each other, in the Brazilians, Californians, Indians, and some South Sea Islanders; and among the latter, the new Caledonians form an insensible transition with the chesnut coloured inhabitants of Tongatabu from the tawny Otaheitans to the black New Hollanders." Blumenbach, l. c. § 43.

"Some tribes of Ethiopians have long hair; (Bruce on the Gallas; African Institution on the people of Bornu) on the contrary, some copper coloured people have the crisp hair of the Ethiopian (The inhabitants of the Duke of York's island, near New Ireland; Vide HUNTER, *Historical Account of the proceedings at Port Jackson*). Again the hair of the New Hollanders, specimens of which I have now before me, is so perfectly intermediate between the crisp hair of the Ethiopian and the curly hair of the islanders of the Pacific ocean, that there has been much diversity of opinion, from the first Dutch to the latest English travellers, to which of the two varieties it should be referred. As to the varieties of colour existing among nations whose hair is usually black, we have sufficient authority for asserting that numerous instances of red hair occur in all the three last varieties." l. c. § 52.

"The Caffres and the people of Congo have hair not unlike that of Eu-often intimately blended in the same individual (indeed all the four varieties run into each other by insensible degrees) ; * and

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ropeans. Even the Foulahs, one of the Negro tribes of Guinea, have, according to Mr. Park, soft, silky hair; on the other hand, the inhabitants of many other countries resemble the Africans in their hair, as the savages of New Guinea, Van Diemen's land, and Mallicollo. And in the same island some of the people are found with crisp and woolly, others with straight hair, as in the New Hebrides. In New Holland there are tribes of each character, though resembling in other particulars." J. C. Prichard, M. D. *Researches into the physical history of Man.* p. 83.

" Many tribes of the Negro race approach very near to the form of Europeans. The Jaloffs of Guinea, according to Park, are all very black, but they have not the characteristic features of the Negro—the flat nose and thick lips: and Dampier assures us that the natives of Natal in Africa have very good limbs, are oval visaged, that their noses are neither flat nor high, but very well proportioned; their teeth are white, and their aspect altogether graceful. The same Author (Dampier's *Voyages*) informs us, that their skin is black, and their hair crisped. Nor are others of this diversity more constant. In the native race of Americans, some tribes are found, who differ not in the characters in question from Europeans. ' Under the 54° 10′ of north latitude,' says Humboldt, ' at Cloak-bay, in the midst of copper-coloured Indians, with small long eyes, there is a tribe with large eyes, European features, and a skin less dark than that of our peasantry.' Humboldt's *Essay on New Spain*, translated." l. c. p. 62. note b.

" The features of the inhabitants of the Friendly Islands are very various, insomuch that it is scarcely possible to fix on any general likeness by which to characterize them, unless it be a fulness at the point of the nose, which is very common. But on the other hand we met with hundreds of truly European faces, and many genuine Roman noses among them.' Cook's last Voyage. Vol. I. 380.

" Similar examples," remarks Blumenbach on this passage (l. c. § 55. note.) " are observed, among Ethiopian and American nations; and, vice versa, the resemblance of individual Europeans to Ethiopians and Mongoles is very frequent and has become even proverbial."

* " The Tartars of the Caucasian variety pass by means of the Kirghises and neighbouring people into the Mongoles, in the same manner as these by means of the people of Thibet into the Indians, by means of the Esquimaux into the Americans, and by means of the Phillippine Islanders even in some measure into the Malays." Blumenbach, l. c. § 86.

instances continually occur of deviation in one or more particulars from the appearances characteristic of any variety: * so that the assemblage rather than individual marks must frequently be employed to determine the variety.

Particular Remarks. The Caucasian variety is pre-eminent in all those mental and corporeal particulars which distinguish man from brutes. It is to the two sexes of this variety that Milton's lines apply,—

> "For contemplation he and valour formed;
> For softness she and sweet attractive grace." †

The cranium is very capacious, the area of the face bears to its area but a proportion of one to four, and projects little or not at all at the lower parts: the intellectual faculties of its individuals are susceptible of the highest cultivation, while the senses of smelling, hearing, and seeing, are much less acute than in dark nations. Philosophy and the fine arts flourish in it as in their proper soil: to it revelation was directly granted.

The Ethiopian variety when instructed by the Caucasian has produced instances of mental advancement great indeed, but inferior to what the latter is capable of attaining. "There scarcely ever," says Hume, "was a civilized nation of that complexion, nor even an individual, eminent either in action or speculation. No ingenious manufactures amongst them, no arts, no sciences. On the other hand, the most rude and barbarous of the whites, such as the ancient Germans, the present Tartars, have still something eminent about them, in their valour, form of government, or some other particulars." ‡ Blumenbach, however, possesses English, Dutch, and Latin poetry written by different negroes, and informs us that, among other examples of distinguished negroes, a native of Guinea, eminent for his integrity, talents, and learning, took the degree of doctor in philo-

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* See note, page 437.

† *Paradise Lost.* Book IV. 297.

‡ Hume, *Essays.* Part 1. Essay 21. Note M.

sophy at the University of Wittenberg, and that Lislet of the isle of France was chosen a corresponding member of the French Academy of Sciences. "Provinces of Europe," says he, "might be named, in which it would be no easy matter to discover such good writers, poets, philosophers, and correspondents of the French Academy; and on the other hand, there is no savage people which have distinguished themselves by such examples of perfectibility, and even capacity for scientific cultivation, and consequently, that none can approach more nearly than the negro to the polished nations of the globe." * This mental inferiority is attended of course by a corresponding inferiority of the brain. The circumference, diameters, and vertical arch of the cranium being smaller than in the European,† and the forehead particularly being narrower and falling back in a more arched form, the brain in general, and particularly those parts which are the organs of intellect properly so called, ‡ must be of inferior size. The orbits, on the contrary, and the olfactory and gustatory or rather masticatory organs being more amply evolved, the area of the face bears a greater proportion to the area of the skull,—as 1. 2. to 4.; the proportion is greater in the orang-outang, and in the carnivora nearly equal.§ The senses here situated, as well as that of hearing, are astonishingly acute, though not only in this but also in the three following varieties, and the corresponding nerves, at least the first, fifth, and facial, of great size.||

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* *Beyträge zur Naturgeschichte.* Th. i. p. 98. Vide Rees's *Cyclopædia*, and Mr. Lawrence's *Lectures.*

† Soemmerring, *De basi cranii et originibus nervorum cranio egredientium.*

‡ Spurzheim, *Physiognomical system.*

§ Cuvier, *Léçons d' Anatomie Comparée.*

|| Soemmerring. l. c.

The native Americans pursue their enemies through the desert by the sense of smell and have distinct terms for the odour of an European, a Negro, and an American Indian. (Humboldt. l. c. Haller. *El. Phys.*) Negroes in the Antilles can distinguish blacks from whites in pursuit by the same sense. The bodies of all men have doubtless a peculiar odour, though the inferior races only enjoy the sense of smell sufficiently acute to make very nice distinctions in regard to it.

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The ossa nasi lie so flatly as to form scarcely any ridge; the face, as we have formerly seen, projects considerably at its lower part;* the lower jaw is not only long but extremely strong; the chin not only not prominent but even receding, and the space between it and the lower teeth is small, while that between the upper teeth and the nose is large; the meatus auditorius is nearer the occiput,—more remote from the front teeth than in the European; the foramen magnum occipitale lying farther back, the occiput is nearly in a line with the spine; the body is slender, especially in the loins and pelvis, whose cavity likewise is small; the length of the fore-arms and fingers bears a large proportion to that of the os humeri; the os femoris and tibia are more

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In them too it is much stronger. I recollect walking one night many years ago with a physician to the house of a poor man in the suburbs of town. The wife came to the door with a candle in her hand, and, opening a dark room on one side of the passage, begged me to walk into it while she lighted the physician to her husband. My nose was presently struck by a very strong smell, something like that of bacon. At the return of the light I perceived three or four little mulattos asleep in a sort of bed, and after leaving the house my friend informed me that the woman's husband was a black.

* Camper, *(Dissertation physique sur les différences réelles, que presentent les traits du visage chez les hommes de différens pays et de différens ages)* gives the following proportions of the facial angle.

European - - - - -	80 or 90
Chinese - - - - -	75
Negro - - - - -	70
Ourang-outang - - - -	58
Monkey - - - - -	42

Mr. White of Manchester *(Essay on the regular gradation)* states them rather differently.

European - - - - -	80 to	90
Asiatic - - - - -	75	80
American - - - - -	70	75
African - - - - -	60	70
Orang-outang - - - -	50	60
Monkey - - - - -	40	50

Cuvier gives 75° for the facial angle of the young orang-outang. l. c. viii. Art. i.

convex, and the edge of the latter, according to a remark of Mr. Fyfe of Edinburgh, very sharp; the calves are placed high; the os calcis instead of forming an arch is on a line with the other bones of the foot, which is of great breadth; the toes are long; the penis large and frequently destitute of frænum. Mr. White, from whom many of these remarks are derived, describes the testes and scrotum as small; the skin is thicker,* and, finally, the term of life generally shorter, than in Europeans.

Nearly all these facts demonstrate rather a less distance of the Negro than of the European from the brute creation. But with an inferiority to the Caucasians so slight if compared with his immense superiority over the most intelligent brutes, so insensibly running into the Caucasian and all the other varieties, so liable to innumerable diversities of conformation as well as bearing some resemblance to brutes, and so certainly bearing no more resemblance to them in some points nor so much in others as many tribes of other varieties, the poor negro might justly class those of us who *philosophically* view him as merely a better sort of monkey or who desire to traffic in his blood, not only below himself but below apes in intellect and below tigers in feeling and propensity.

> "Indica tigris agit rabida cum tigride pacem
> Perpetuam. Sævis inter se convenit ursis." †

The Malays have but little hair upon the chin and possess a great developement of the parts of the head above the ears.

The Mongolians are remarkably square and robust; their shoulders high; their extremities short and thick.

The Americans have small hands and feet, and are nearly destitute of beard. Shorter in the forehead than the Mongolians, they have not so great intellectual distinction.

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* The temperature of the Negro has been said to be two degrees cooler than that of Europeans, and the voluptuous therefore to prefer a Negress in summer, a fair Circassian in spring and autumn, and an European brunette in winter.

† Juvenal. *Sat.* xv. 163.

‡ Spurzheim, *Physiognomical System.*

Not only have the five varieties their distinctive characteristics, but the different nations comprehended in each variety have each their peculiarities, both mental and corporeal: among the Caucasians, for example, the Germans, French, Spaniards, and English are extremely different from each other. Nay, the provinces of the same country differ, and the families of the same province, and, in fact, every individual has his own peculiar countenance, figure, constitution, form of body, and mental character.

A QUESTION here presents itself.—Are the differences among mankind to be ascribed to the influence of various causes upon the descendants of two,—or of more, but all similar, primary parents;—or to original differences in more than two primary parents? If *considerations à priori, analogical and direct facts,* and *the history of mankind,* corroborate in conjunction the first supposition, there will be no necessity to have recourse to the bolder second, nor to the third—the boldest of the three.

On the point before us the Bible speaks positively and clearly, without the possibility of various interpretation or corruption of the text, and not only in the account of the creation, but incidentally in many other places.* It is delightful to find nature

* Mr. Lawrence in the article MAN of Rees's *Cyclopædia* says that the book of Genesis does not clearly assert that Adam and Eve were the parents of mankind. But, however allegorical the account of the fall and some other circumstances may be, and however little entitled to the name of any thing more than records of facts and opinions many portions of the *Old Testament* may appear to some persons, we shall find, if we read the whole Bible, that our descent from Adam and Eve is frequently alluded to, both in the Old and New Testament, and not merely as an indifferent fact, but as one of the fundamental truths of revelation; and thus any supposed obscurity in the book of Genesis completely dispelled. His object, however, seems not to charge Moses with obscurity, but with contradiction. He says,—" We are told indeed that ' Adam called his wife's name Eve, because she was the mother of all living.' But in the first chapter of Genesis we learn, that God created man, male and female, and this seems to have been previously to the formation of Eve, which did not take place till after the garden of Eden had been made. Again we are informed, in the fifth chapter of Genesis, that ' in the day God

and history investigated already so far as to harmonise with the

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created man, in the likeness of God, created he him; male and female created he them; and blessed them and called their name Adam, in the day when they were created.'" Now the second chapter of Genesis is a recapitulation, and, at the same time, a more circumstantial detail, of what is contained in the first. In the first, the man and woman are said to have been created on the sixth day; in the second, we are further informed how and in what order each was formed, —that the man was formed of the dust of the earth and placed in the garden of Eden (planted, it appears from perusing the whole of the second chapter, before his creation no less than before that of Eve), where he fell into a deep sleep, during which the woman was formed from a part of his body. Is this contradictory, or even obscure?

"We find also," continues this writer, (in the very words of Mr. White of Manchester, without the least hint of quotation,) "that Cain, after slaying his brother, was married, although it does not appear that Eve had produced any daughters before this time. 'Cain went out from the presence of the Lord, and dwelt in the land of Nod, on the east of Eden. And Cain knew his wife, and she conceived and bare Enoch.' Indeed, it is said (ch. 5. v. 4.) that 'the days of Adam, after he had begotten Seth, were eight hundred years, and he begat sons and daughters.' This it should seem took place after the birth of Seth, and consequently, long after Cain had his wife; for Seth was not born till after the death of Abel. If Cain had sisters prior to that period, from amongst whom he might have taken a wife, it is singular, as some persons may allege, that Moses should not have noticed them." By no means singular. Moses relates a few most important circumstances only, just sufficient to carry on the history from the creation: the first six chapters comprehend a period of no less than sixteen hundred and fifty-six years. Although the marriages of Adam's descendants are continually alluded to, yet as the successions and periods of the births of the men only were important to his history, he does not, I believe, individually mention, during the first nineteen hundred and fifty years of his history, the daughter of any particular person. His silence in this particular is conspicuously seen in the fifth chapter, for example, where, after mentioning the birth of the first son and the amount of the subsequent years of the father's life, he merely adds, "and begat sons and daughters;" not only in regard to Adam, but to his descendants. He passes over in silence even individual sons, when they constitute no link, and are connected with no remarkable circumstance, in his history of our race.

As a believer in Christianity, and, I trust, upon *rational* conviction, I earnestly entreat all who are inclined to despise the Scriptures, to distinguish between the sublimity and purity of Christianity and the ignorance, bigotry, and statement of holy writ, but I shall of course detail the arguments quite independently of this consideration.*

A priori, I think, the universal simplicity of nature's causes would induce us to imagine that, as, if the varieties among us are accidental, two individuals were evidently sufficient for the production of the rest of mankind, no more than two were originally created. Nor can I conceive it possible to deduce a contrary presumptive argument from the length of time during which immense portions of the earth must have thus remained unpeopled. One of nature's objects seems the existence of as much successive life as possible, whether animal or vegetable, throughout the globe. For this purpose every species of animal and vegetable possesses an unlimited power of propagation, capable of filling the whole world, were opportunity afforded it. The opportunities of exertion are indeed very scanty, compared

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hypocrisy, of many who profess it, and to suspend their hostility to the religion of Bacon, Newton, Locke, and Milton, till they have dispassionately studied at least the four gospels, and the works of Bishops Butler and Watson, of Archdeacon Paley, Dr. Chalmers, and Mr. Leslie.

I never met with a sceptic who would pretend to any acquaintance with the overpowering evidences of Christianity. "Hume owned to a clergyman in the bishopric of Durham, that he had never read the New Testament with attention." (Boswell's *Life of Johnson.* Vol. ii. p. 7. fifth edition.)

The depravity of too many young persons who, in their ingenuous admiration of some men of talent, have blindly adopted their scepticism, forgetting that knowledge of one subject does not imply knowledge of others or freedom from prejudice and vanity, is unhappily notorious.

* All the brutes of each species appear descended from one stock, for the brutes of the old and new world are all of distinct species, excepting in the northern regions, where a communication is very explicable. The same is true of the brutes of the arctic and antarctic regions: prevented, like the more equatorial brutes of the two hemispheres, by the intermediate climate, from communicating with each other, they are all of distinct species. In islands remote from continents, either no quadrupeds are found, or such as may have been conveyed thither, or such as are different from any others; while in islands near continents, the quadrupeds are the same as in the neighbouring country. This point is ably handled by Dr. Prichard, l. c.

with the power: climate, soil, situation, may be unfavourable; one vegetable, one animal, stands in the way of another; even the impediments to the increase of some, act through them as impediments to others. The incessant tendency of the power of multiplication to exert itself, seizes every opportunity the moment it is presented, and thus, though every living object has a fixed term of existence and may be carried off much earlier by innumerable circumstances, all nature constantly teems with life.* The slow increase of mankind could not interfere with this apparent object of nature; the deficiency of our race must have invariably been fully compensated by the opportunities which it afforded for the multiplication of other existences: for that man alone was not designed to enjoy the earth, is shown by the vast tracts of land still but thinly peopled. The infinitely rare opportunities afforded for the maturity of the intellectual and moral powers born with every human being, may afford still greater surprise than the extent of country unoccupied by man. After all, the great length of life in the early periods of the world must have contributed so much to man's multiplication that, if food was sufficiently supplied, he might very speedily have covered the earth.

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* From this physiological fact it follows that if a species is not kept down by disease or violence, or, as should be the case with mankind, by good feeling, to such numbers as can find support, the excess must regularly perish. To vegetables this can be no cruelty. As all the brute creation are preyed upon, their numbers may be always sufficiently thinned without starvation. Violent deaths are too insignificant to operate much in restraining the numbers of mankind, and terrible as is the havoc of disease, the rapid increase of nations, who can command any extent of land they require for food, proves *it* not to be the great restrainer of population. Starvation, however, is not necessary to limit our numbers, because it is the imperious duty of every man to abstain from getting children unless he has property or work sufficient to feed them when they come into the world.

These palpable facts have been luminously stated by a celebrated member of my own college at Cambridge, and how any one can deny them or pretend there is impiety in Mr. Malthus's *Essay on Population*, I cannot comprehend.

Analogical and direct facts lead us to conclude that none of the differences among mankind are so great as to require the belief of their originality.

Animated beings have a general tendency to produce offspring resembling themselves, in both mental and corporeal qualities.

> " Fortes creantur fortibus et bonis;
> " Est in juvencis, est in equis patrum
> " Virtus: nec imbellem feroces
> " Progenerant aquilæ columbam."*

An exception occasionally occurs, much more frequently indeed in the domestic than the wild state,—the offspring differs in some particular from the parents; and by the force of the general tendency transmits to its offspring its own peculiarity. By selecting such examples, a breed peculiar in colour, figure, the form of some one part, or in some mental quality, may be produced. Thus, by killing all the black individuals which appear among our sheep and breeding from the white only, our flocks are white; while, by an opposite practice pursued in some countries, they are black: thus a ram accidentally produced on a farm in Connecticut, with elbow-shaped fore-legs and a great shortness and weakness of joint indeed in all four extremities, was selected for propagation, and the ἀγκὼν breed, unable to climb over fences, is now established: † thus some breeds of hares have horns like the roebuck: the Dorking fowl has two hind claws; and fowls indeed are bred in every conceivable variety.‡ Individuals, distinguished from others by no greater

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* *Horace.* L. iv. od. 4.

† Thomson's *Annals of Philosophy.* No. 2.

‡ The offspring most frequently resembles both parents, but the proportion of resemblance to each, both on the whole and in regard to particular parts, is various,—some children favouring the father most, some the mother, though usually resembling each enough to preserve a family likeness,—some parts being as it were an equable compound of the same in both parents, (as the skin in the mulatto offspring of a black and white) some an unequal compound, (as when the offspring of a black and white is white with patches of black, or

differences than those which thus spring up accidentally, cannot be supposed to belong to a separate species. Upon the comparison of these differences depends the analogical argument first employed by Blumenbach. Finding the ferret *(mustela furo)* to differ from the pole cat *(m. putorius)* by the redness of its eyes, he concludes it is merely a variety of the same species, because instances of this deviation are known to occur accidentally in other animals; but he concludes the African elephant is of a

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with merely a black penis. *Phil. Trans.* Vol. 55. Bartholin, *Hist. Anat.* Schurig, *Spermatologia.* p. 146.), and others again similar to the same as seen in one parent only; and it is remarkable that the resemblance to the parents, whether in regard to common or singular peculiarity, is occasionally not observed in the immediate offspring, but re-appears in the third or even a later generation.

As the different properties of both parents are on the whole pretty well blended in the offspring, we may, by breeding successively from offspring and one of the original parents, at length produce an offspring exactly resembling this parent. (590) Some abandoned Europeans are said to have begun with a black woman, and copulated with their offspring till they made her the great grandmother of a white.

National features, form, and in a great measure even character, arise from a nation marrying among themselves, and will be more marked in proportion to the rarity of connection with foreigners. Hence the amazing peculiarity of the Jewish race.

The advantage of crossing breeds is well known, and may be explained by the transmission of the parents' qualities. If any unfavourable deviation in structure or constitution occurs, and is transmitted, and the descendants who receive it hereditarily intermarry, the deviation is doubly enforced in their offspring: but if a connection is made with another family or breed it is, on the contrary, diluted. Could a race, however, have all its wants well supplied, and, at the same time, have no unhealthful habit, so as to acquire no tendency (page 459) to unfavourable deviation, I do not think that the soundness of breeds would require crosses. The Arabians never allow the mares of the noble race to be covered by any but stallions of their own rank, yet the excellence of the breed is maintained. (D'Arvieux, *Travels in Arabia.* p. 168.) Their horses have every comfort, and yet are not subjected, like our domestic animals and most of ourselves, to unnatural habits. The degeneracy of many plants unless their *soil* is changed, is quite another circumstance.

species distinct from the Asiatic, because the invariable difference of their molar teeth is of a description which naturalists have never found accidental. Now there exist among mankind no differences greater than what happen occasionally in separate species of brutes.

The colours of the animals around us, horses, cows, dogs, cats, rabbits, fowls, are extremely various,—black, white, brown, grey, variegated.

The hair of the wild Siberian sheep is close in summer, but rough and curled in winter; * sheep in Thibet are covered with the finest wool, in Ethiopia with coarse stiff hair; † the bristles of the hog in Normandy are too soft for the manufacture of brushes; ‡ goats, rabbits, and cats of Angouri, in Anatolia, have very long hair, as white as snow and soft as silk. §

The head of the domestic pig differs as much from that of the wild animal, as the Negro from the European in this respect; || so the head of the Neapolitan horse, denominated ram's head on account of its shape, from that of the Hungarian animal, remarkable for its shortness and the extent of its lower jaw; ** the cranium of fowls at Padua is dilated like a shell and perforated by an immense number of small holes; †† cattle and sheep in some parts of our own country have horns, in others not; in Sicily sheep have enormous horns; ‡‡ and in some instances this animal has so many, as to have acquired the epithet polyceratous.

The form of other parts is no less various. In Normandy, pigs have hind-legs much longer than the fore; §§ at the Cape of Good Hope, cows have much shorter legs than in England; |||| the difference between the Arabian, Syrian, and German, horses

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* Pallas, *Spicileg. Zoologica.*

† Blumenbach, l. c. § 28. ‡ l. c.

§ l. c. || l. c. ** l. c.

†† Pallas, *Spic. Zool.* fasc. iv. p. 22. Sandifort, *Museum Anatonicum Acad.* Lugd. Batav. T. i. p. 306.

‡‡ Blumenbach, l. c. § 30. §§ l. c. |||| l. c.

is sufficiently known; the hoofs of the pig may be undivided, bisulcous, or trisulcous.

These are regarded by naturalists as but accidental varieties, yet they equal or surpass the varieties existing among mankind. We are consequently led by analogy to conclude, that the differences of nations are not original but acquired, and impose no necessity for believing that more than one stock was at first created.

Direct facts harmonise with this conclusion. All races run insensibly one into another, and therefore innumerable intermediate examples occur where the distinction between two varieties is lost. Again, no peculiarity exists in any variety which does not show itself occasionally in another. Many instances of these facts have been already related (page 437, note *). The difficulty of regarding the negro as of the same stock with ourselves vanishes on viewing these circumstances and on reflecting that he and ourselves are two extremes, one of which may have sprung from the other by means of several intermediate deviations, although experience may not justify us in supposing any single deviation of sufficient magnitude.* Lastly, both the males

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* In regard to colour, however, the Albino proves how great a change may take place in one generation. In the *Memoirs of the London Medical Society*, (Vol. iii.) is described a case, where not only patches of the hair of the head of an European changed from black to perfect white, first on one side and then on the other, and in the course of seven years every hair became white excepting the eyebrows, but the skin also from being swarthy became fair. (I may add that the irides remained unchanged, and that another case is annexed to it where half the hair was black and lank, and the other half light and frizzled.) I recollect accounts of three persons who belonged to the dark races, turning white,—one of a negress, in Maryland, forty years of age, who had been turning white during the last fifteen years, and had become scarcely inferior in any part of her surface to an European, and was still changing, (*Phil. Trans.* Vol. li.),—one of a man, born in Bengal, near sixty years of age, who left India in his tenth year, and had for nine years been changing to white. (Dr. Duncan, Jun. *Reports in the Practice of the Clinical Ward of the Royal*

and females of all the varieties breed together readily and in perpetuity,*—an assertion which cannot be made in regard to any different species of brutes.

The cause of the differences of our species has been more or less sought for in climate, alone or in conjunction with other external circumstances, by Aristotle, Hippocrates, Cicero, Pliny, Plutarch, Galen, nearly all the Greek and Roman historians and poets, Montaigne, Montesquieu, Buffon, Zimmerman, Blumenbach, Dr. Smith of America, &c. Lord Kaimes has denied the power of these circumstances to produce the diversities of either mind or body; and Hume has expressly written an essay to prove the insufficiency of climate with respect to the varieties of national character. Now the intensity of light unquestionably affects the colour of the surface, although not to the degree of Ethiopian blackness; heat the texture and growth of the hair; and quantity of nourishment the size. But the effects of these circumstances are superficial, even on animals necessarily less protected against their influence than man. The skulls of foxes belonging to northern regions are not different from those of France or Egypt: the tusks of the elephant, and the horns of the stag and rein deer, may acquire a larger size when the food is more favourable to the production of ivory or horn, but the number and articulations of the

Infirmary of Edinburgh. 138.),—one mentioned by the Duc de Rochefoucault Liancourt, (*Travels through the United States*. Vol. iii. p. 263.). A Sussex girl was, a few years ago, a patient in St. Thomas's Hospital, whose family were all white, but whose left shoulder, arm, and hand, were of a negro blackness, except that a stripe of white ran between the elbow and arm-pit. (Dr. Wells's *Works*.) A white woman in twenty years became as black as a negress, without any evident reason, according to a statement in the *London Medical and Physical Journal*. (1811. p. 24.); and other such cases may perhaps be discovered, though those which I have read appear to have been instances of cutaneous disease.

* An example has already been mentioned (563* B.) of what is a still stronger argument,—the *simultaneous* production of two individuals of different varieties,—of a negro and a caucasian, by the same mother.

bones, and the structure of the teeth, remain unaltered.* Nor are these changes, any more than those induced by mechanical means, as pressure, division, &c. transmitted to the offspring: the child of the most sunburnt rustic is born equally fair with other children; even all the children among the Moors are born white and acquire the brown cast of their fathers only if exposed to the sun;† although the Jews have most religiously practised the rite of circumcision from the days of Abraham, their foreskin still remains to be circumcised.‡ Were it therefore true that all dark nations are the inhabitants of hot climates, as the confined knowledge of the antients justified them in believing, it would still be untrue that the change effected, for instance, in the colour of the parent's skin, had descended to the offspring. But modern discovery has made us acquainted with light nations, inhabiting the warmest regions, with dark nations inhabiting the coldest, and with others of various shades of colour although in the same climate.§ Many protected parts are

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* Cuvier, *Discours Préliminaire aux Récherches sur les Ossemens Fossiles des Quadrupèdes. Natural varieties* only are meant. Local situation can produce the most intimate structural *diseases;* witness Cretinism.

† Poiret, *Voyage en Barbarie.* T. i. p. 31. Vide Blumenbach, l. c.

‡ Paley, *Natural Theology.* Ch. 23. p. 472.

§ Lord Kaimes, M. de Virey, and Dr. Prichard, have quoted many instances of these facts. 'We found,' says Humboldt, 'the people of the Rio Negro swarthier than those of the lower Orinoco, and yet the banks of the first of these rivers enjoy a much cooler climate than the more northern regions. In the forests of Guiana, especially near the sources of the Orinoco, are several tribes of a whitish complexion, the Guiacas, Guajaribs and Arigues, of whom several robust individuals exhibiting no symptom of the asthenical malady which characterises Albinos, have the appearance of true Mestizos. Yet these tribes have never mingled with Europeans, and are surrounded with other tribes of a dark brown hue. The Indians, in the torrid zone, who inhabit the most elevated plains of the Cordilleras, of the Andes, and those who are under the 45° of south latitude, have as coppery a complexion as those who under a burning climate cultivate bananos in the narrowest and deepest vallies of the as black as those which are exposed. Nor are the varieties of mankind more dependent upon the varieties of food.

Equinoctial region. We must add that the Indians of the mountains are clothed, and were so long before the conquest, while the Aborigines, who wander over the plains, go quite naked, and are consequently always exposed to the perpendicular rays of the sun. I could never observe that in the same individuals those parts of the body which were covered were less dark than those in contact with a warm and humid air. We every where perceive that the colour of the American depends very little on the local position in which we see him. The Mexicans, as we have already observed, are more swarthy than the Indians of Quito and New Granada, who inhabit a climate completely analogous, and we even see that the tribes dispersed to the north of the Rio Gila are less brown than those in the neighbourhood of the kingdom of Guatimala. This deep colour continues to the coast nearest to Asia, but under the 54° 10′ of north latitude, at Cloak Bay, in the midst of copper coloured Indians, with small long eyes, there is a tribe with large eyes, European features, and skin less dark than that of our peasantry.' *Political Essay on New Spain*, translated.

The Jews settled in the neighbourhood of Cochin 'are divided into two classes, called the Jerusalem or white Jews, and the ancient or black Jews.'—'The white Jews look upon the black Jews as an inferior race, and not as a pure cast, which plainly demonstrates that they do not spring from a common stock in India.' Buchanan, *Christian Researches in Asia*. 219, &c.

The white appear to have resided there upwards of seventeen hundred years.

Dr. Shaw and Mr. Bruce describe a race of fair people in the neighbourhood of Mount Aurasius, in Africa, who, 'if not so fair as the English, are of a shade lighter than that of any inhabitants to the southward of Britain. Their hair also was red, and their eyes blue.' They are imagined to be descendants of the Vandals. Bruce, *Travels*.

The Samoiedes, Greenlanders, Laplanders, Esquimaux, &c. are very swarthy; nay, some of the Greenlanders are said to be as black as Africans.

'Do we not in fact behold,' says M. de Virey, 'the tawny Hungarian, dwelling for ages under the same parallel and in the same country with the whitest nations of Europe; and the red Peruvian, the brown Malay, the nearly white Abyssinian, in the very zones which the blackest people in the universe inhabit? The natives of Van Diemen's land are black, while Europeans of the corresponding northern latitude are white, and the Malabars, in the most burning climate, are no browner than the Siberians. The Dutch, who have resided more than two centuries at the Cape of Good Hope, have not acquired

With civilisation and barbarism, however, they appear certainly connected. We should beforehand be inclined to imagine that the most excellent developement of every animated species would be effected where all its wants were best supplied, its powers all duly called forth, and all injurious or unpleasant circumstances least prevalent: and vice versa. Every one knows the effect of cultivation in the vegetable kingdom. But experience teaches us that no change brought about in an animal after birth can be transmitted to the offspring: the causes of change in a species must therefore operate, not by altering the parents, but by disposing them to produce an offspring more or less different from themselves. (Such is Mr. Hunter's view of the question,* and it is certainly confirmed by every fact.†) Uncivilised nations exposed to the inclemency of the weather, supported by precarious and frequently unwholesome food, and having none of the distinguishing energies of their nature called forth, are generally dark coloured and less distant from brutes in conformation;

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the sooty colour of the native Hottentots; the Guebres and Parsees, marrying only among themselves, remain white in the midst of the olive-coloured Hindus.' J. T. Virey, *Histoire Naturelle du genre humain.* Tome premier. p. 124.

* I fear Mr. Hunter has not generally the credit of this observation, but the following passage shows it to be clearly his. "As animals are known to produce young which are different from themselves in colour, form, and disposition, arising from what may be called the unnatural mode of life, it shews this curious power of accommodation in the animal economy, that although education can produce no change in the colour, form, or disposition of the animal, yet it is capable of producing a principle which becomes so natural to the animal that it shall beget young different in colour and form; and so altered in disposition, as to be more easily trained up to the offices in which they have been usually employed; and having these dispositions suitable to such changes of form." Hunter, *On the wolf, jackall, and dog.* l. c.

† May not some circumstances that produce a change in the offspring by acting *through* the parent, produce the same change likewise *in* the parent, although the *change* in the latter is *not* the cause of the change in the offspring?

while those who enjoy the blessings of civilisation, i. e. good food and covering, with mental cultivation and enjoyment, generally acquire in the same proportion the Caucasian characteristics. The different effects of different degrees of cultivation, says Dr. Smith, "are most conspicuous in those countries in which the laws have made the most complete and permanent division of ranks. What an immense difference exists in Scotland between the chiefs and the commonalty of the highland clans. If they had been separately found in different countries, the philosophy of some writers would have ranged them in different species. A similar distinction takes place between the nobility and peasantry of France, Spain, of Italy, of Germany. It is even more conspicuous in eastern nations, where a wider difference exists between the highest and the lowest classes in society. The naires or nobles of Calicut, in the East Indies, have with the usual ignorance and precipitancy of travellers been pronounced a different race from the populace; because the former, elevated by their rank, and devoted only to martial studies and achievements, are distinguished by that manly beauty, and elevated stature so frequently found with the profession of arms; especially when united with nobility of descent; the latter poor and laborious, and exposed to hardships without the spirit or the hope to better their condition, are much more deformed and diminutive in their persons, and in their complexion much more black. In France, says Buffon, you may distinguish by their aspect not only the nobility from the peasantry, but the superior orders of nobility from the inferior, these from citizens, and citizens from peasants."—"The field slaves in America," continues Dr. Smith, "are badly clothed, fed, and lodged, and live in small huts on the plantations, remote from the example and society of their superiors. Living by themselves, they retain many of the customs and manners of their ancestors. The domestic servants, on the other hand, who are kept near the persons, or employed in the family of their masters, are treated with great lenity, their service is light, they are fed and clothed like their superiors, they see their manners, adopt their habits, and insensibly receive the same ideas of elegance and beauty. The field slaves are in consequence slow in changing the aspect and figure of Africa. The domestic servants have advanced far before them in acquiring the agreeable and regular features, and the expressive countenance of civilised society. The former are frequently ill shaped, they preserve in a great degree the African lips, and nose and hair. Their genius is dull, and their countenance sleepy and stupid. The latter are straight and well proportioned, their hair extended to three or four, sometimes even to six or eight inches: the size and shape of their mouth handsome, their features regular, their capacity good, and their look animated." *

Dr. Prichard has 'been assured by persons who have resided in the West Indies, that a similar change is very visible among the Negro slaves of the third and fourth generation in those islands, and that the first generation differs considerably from the natives of Africa.' †

The South Sea Islanders, who appear to be all of one family, vary according to their degree of cultivation. The New Zealanders, for example, are savages and chiefly black; the New Hollanders are half civilised and chiefly tawny; the Friendly Islanders are more advanced and are not quite so dark, several are lighter than olive colour, and hundreds of European faces are found among them.

The people of Otaheite and the Society isles are the most civilised and the most beautiful: the higher orders among them have a light complexion and hair flowing in ringlets; the lower orders, less cultivated, are less pleasing.

" The same superiority," says Captain King, ‡ 'which is ob-

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* *On the Causes of the variety in the Complexion and Figure of the human species.* p. 85 sq.

† l. c. page 227. note.

‡ Cook, *Voyages.* Vol. iii. book v. ch. 7.

servable in the Erees (nobles) throughout the other islands, is found also here (Owyhee). Those whom we saw, were, without exception, perfectly well formed; whereas the lower sort, besides their general inferiority, are subject to all the variety of make and figure that is seen in the populace of other countries." *

Climate, however, has not been shewn to have no effect: but its power, being in itself not very considerable, cannot be strongly manifested when opposed. In fact, a diminution of the sun's influence does dispose to the production of light varieties: the inhabitants of hilly situations are, cæteris paribus, fairer than the people below, and persons of the same tribe and degree of civilisation lighter in the northern parts of Europe and Asia than those in the more southern; whiteness, too, is very common in the north among animals which nearer the equator are variously coloured; a pair of brown mice kept in a dark place are said to generate a white offspring.

Perfection, in other words, the highest compatible point of utility or agreeableness, or of both, is nature's universal aim in her productions, but it is in general obtained slowly, and the more so in proportion to the excellence or degree of the qualities to be perfected. Animals and vegetables have to pass one period before they burst into birth, and another before their full powers and proportions are reached; and man, whose perfections are very excellent, arrives at his acmé very late.

It is in this respect with species as with individuals,—their improvement is gradual.

In conformity with such observations, some suppose that all mankind were once so far below the excellence of which they are susceptible,—that this was to be acquired so slowly, that the Caucasian variety once did not exist. They support this opinion by the remark of Mr. Hunter,—that the changes of colour in

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* If the kingdom of Hayti continues, some highly interesting physiological questions will be determined:—We shall know what cultivation the African race is capable of, and what influence civilisation has upon the system.

brutes are always from the darker to the lighter shades,* by occasional instances of individual blacks turning permanently white, whereas individual whites have rarely been known to turn black, and by the asserted probability of the most ancient people of the earth, from whom Europeans must be descended, having been genuine Ethiopians or Negroes.†

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* 'Animals living in a free and natural state are subject to few deviations from their specific character; but nature is less uniform in its operations, when influenced by culture. Considerable varieties are produced under such circumstances; of which the most frequent are changes in the colour.

'These changes are always, I believe, from the dark to the lighter tints; and the alteration very gradual in certain species, requiring in the canary-bird several generations; while in the crow, mouse, &c. it is completed in one. But this change is not always to white, though still approaching nearer to it in the young than in the parent; being sometimes to dun, at others to spotted, of all the various shades between the two extremes. This alteration in colour being constantly from dark to lighter, may we not reasonably infer, that in all animals subject to such variation, the darkest of the species should be reckoned nearest to the original; and that where there are specimens of a particular kind, entirely black, the whole have been originally black? Without this supposition it will be impossible, on the principle I have stated, to account for individuals of any class being black. Every such variety may be considered as arising in the cultivated state of animals.' Hunter, *On the colour of the pigmentum nigrum of the eye.* l. c. p. 243.

† Dr. Prichard. l. c. Chap. vii. viii. ix.

I shall take this opportunity of noticing monsters.

Mr. Lawrence has collected many remarkable and well authenticated instances of monsters, in a paper published in the fourth volume of the Medico-Chirurgical Transactions. To this I refer for examples. He divides monstrosity into unnatural formation, unusual position of certain organs, deficiency, redundancy, and a mixture of these.

Monstrous formation is a frequent cause of miscarriage. Autenreith observes, "that he found three abortions monstrous out of nineteen whose parts could be distinguished; that Wrisberg met with two among five; and Ruysch two in twelve:—altogether seven to twenty-nine." Sömmerring states that most monstrous embryos are of the male sex.

When any very considerable deviation of structure exists, there are usually others of less magnitude. A sound offspring is very frequently born at the

The history of mankind supports the same inference as considerations à priori and analogical and direct facts. All the na-

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same time with a monstrous production, and monstrous productions occasionally alternate with well formed beings.

No one in the present day would ascribe monstrosity to any thing else than an error in the original materials of the embryo,—to a mixture of the whole or a part of the materials of two or more embryos, to a deficiency in the materials, or to a derangement of them. (587. 3. 588. 591.)

Culture we find produces alterations in animated beings. If it proceeds no farther than to afford a supply to all the natural wants of a system, it improves the species, as is exemplified daily in vegetables. "It may certainly be laid down, says Mr. Hunter, (l. c. p. 245 note) as one of the principles or laws of nature, to deviate under certain circumstances. It may also be observed, that it is neither necessary nor does it follow, that all deviations must be a falling off: it appears just the contrary, therefore we may suppose that nature is improving its works, or, at least, has established the principle of improvement in the body as well as in the mind." If, however, luxurious abundance is supplied or important natural habits of the system prevented, as is not rarely the case in domesticated brutes and civilised man, deviation may advance beyond improvement and actually become degeneration or monstrosity. Hence the commonly known fact (591) of monsters being frequent among domesticated animals and rare among the wild. As man by his depravity commits errors and excesses of every description, unnecessarily mingling ill effects with the benefits of civilisation, no wonder that monsters are common among the human species. The evils of civilisation are not necessarily united with it, and, great as they are, they fall infinitely short of its benefits. Without civilisation, population must be wretchedly small, exigencies and comforts miserably supplied, and none of the noble characteristics of the head and heart fully called forth: in the uncivilised state, on which Mr. Lawrence is disposed to bestow such eulogies in the Medico-Chirurgical Transactions, this gentleman's superiority would not have been conspicuous. In his lectures, however, he evinces a happy change of sentiment, is repeatedly at considerable pains to display the blessings and naturalness of civilisation, and quotes PERON's *Voyage des Découvertes aux terres australes*, in proof of even the superior physical power of civilised men. Peron's experiments were introduced to medical men in the Edinburgh Medical and Surgical Journal ten years ago. By means of Regnier's Dynamometer he ascertained the bodily power of the complete savage of Van Diemen's land to be inferior to that of the more cultivated New Hollander, of the latter to that of the still more cultivated inhabitant of Timor, and of the last very considerably to that of Europeans. The weakest Frenchman was equal in the hands tions of the earth appear to have branched forth from one quarter. Dr. Prichard has traced them with great learning and judgment,

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to the strongest man of Van Diemen's Land, and the weakest Englishman stronger than the strongest New Hollander: the *average* strength of Europeans in the loins exceeded that of the most powerful individuals of either Van Diemen's Land, New Holland, or Timor.

Mr. Lawrence, I mention it with pain, appears to draw, from the occurrence of monsters, an argument unfavourable to the belief of the goodness of the Almighty. This, I am aware, is not the place to 'assert eternal providence, and justify the ways of God to man;' but in recommending the student to a work, it is my duty to guard him against its disadvantages. "Neither should we overlook these productions (says this gentleman) in our attempts to infer from the phenomena of nature, and particularly from organized beings, the character of the cause which has produced them. Creatures so imperfectly constructed, as to be incapable of independent vitality, and consequently perishing immediately after they are born; and those whom the malformation of some organ draws, after a life of pain and misery, afflicting to themselves and burthensome to others, to a premature death, offer an apparent exception to the inferences, which have been drawn from the animal kingdom in general, concerning some attributes of the creating power." "Archdeacon Paley has passed over the subject in silence." Something is added about the infallibility of revelation, but the sarcastic mode of expression, even if not coupled with passages in various other parts of his writings, renders the meaning but too suspicious.

The world, it must be remembered, is governed "not by partial, but by general, laws," and the least reflection will shew that the most trivial alteration which a human being could propose in any one of them, would produce infinite mischief. In particular circumstances, however, the good they generally cause, is certainly converted into evil. Hunger is one of the great sources of activity and enjoyment among men and brutes, but in particular circumstances,—where it cannot possibly be gratified, it is a mere torment. The laws of each species of organic formation produce the beautiful animated system, but these same laws under particular thwarting circumstances,—when crossed by other general laws, produce monsters. The case of monsters is but one of numerous similar examples, and, although Paley has not noticed this example individually, he notices all such in general. "Contrivance proves design; and the predominant tendency of the contrivance indicates the disposition of the designer. The world abounds with contrivances, and all the contrivances which we are acquainted with, are directed to beneficial purposes. Evil, no doubt, exists;

and, as the subject has not been made by myself a matter of original research and is far too extensive to be handled here as it

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but is never, that we can perceive, the object of contrivance. Teeth are contrived to eat, not to ache; their aching now and then is incidental to the contrivance, perhaps inseparable from it, or even, if you will, let it be called a defect in the contrivance; but it is not the *object* of it. This is a distinction which well deserves to be attended to. In describing implements of husbandry, you would hardly say of the sickle, that it is made to cut the reaper's fingers, though, from the construction of the instrument, and the manner of using it, this mischief often happens. But if you had occasion to describe instruments of torture or execution, this engine you would say, is to extend the sinews; this to dislocate the joints; this to break the bones; this to scorch the soles of the feet. Here pain and misery are the very *objects* of the contrivance. Now nothing of this sort is to be found in the works of nature. We never discover a train of contrivance to bring about an evil purpose. No anatomist ever discovered a system of organisation (i. e. no species of system of organisation, for the laws of the formation of an individual are the general laws of the species to which it belongs) calculated to produce pain and disease; or in explaining the parts of the human body, ever said, this is to irritate; this to inflame; this duct is to convey the gravel to the kidneys; this gland to secrete the humour which forms gout. If by chance he come at a part of which he knows not the use, the most he can say is, that it is useless: no one ever suspects that it is put there to incommode, to annoy, or to torment. Since then God hath called forth his consummate wisdom to contrive and provide for our happiness, and the world appears to have been constituted with this design at first, so long as this constitution is upholden by Him, we must in reason suppose the same design to continue." *Moral Philosophy*. vol. i. p. 76.

"The evil and the good," says Bishop Watson, "necessarily spring from those laws of matter and motion, to which we and all other animals inhabiting this earth are now subjected; nor, whilst these laws subsist, is it possible that the evil could have been avoided and yet the good produced; they must of necessity both exist together; and if the good outweighs the evil (as it unquestionably does, if we take into consideration the whole of any species) we may be certain that a benevolent Being is the author of both.

"Unanimated matter is incapable of either pleasure or pain; it cannot be the subject of either good or evil. But all the parts of this terraqueous globe, and the air which surrounds it, are filled with various species of animals, all of them, collectively taken, deriving pleasure from their existence. Now pleasurable sensations are a positive good derived from God having animated a certain portion of matter; the quantity of this good we know not how to estimate, but we deserves, I must refer to his work which is both the most recent and the best, contented with simply inserting his conclusion,

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do know the source from which it springs—it is produced by the will of a benevolent Being; for, had the Being which produced it, been malevolent, he would have produced a preponderance not of good but of evil. Being certain, then, from the things which are made, that benevolence is the attribute of the God who made them, we have the strongest reason to believe that no natural evil exists in his works, which could have been prevented without the loss of a greater good."—Bp. of Landaff, *Miscellaneous Tracts, &c.* Serm. iv.

Even where evil is produced, such is the mighty universal plan, that it proves not simple, solitary evil, but becomes the cause of innumerable good effects. A severe misfortune has often converted a proud and prejudiced man into one of modesty and candour. Again the stupendous wisdom and the benevolence of the Almighty are continually manifested in the operation of one general law preventing the *particular* evil resulting occasionally from the clashing of others. Thus a large number of monsters perish in the womb (458); of those which are born, many die the moment of their birth or a few days afterwards; of those which survive, many die during childhood; and of those few which grow up, very few reach, and perhaps none, whose singularity is very great, pass, the middle period of life, and their organs of procreation are often languid, if not perfectly inefficient: nor in fact do I believe from my observation that many of those who grow up are at all less happy than other people.

Is there not benevolence enough displayed to prove the completely benevolent disposition of the Creator? Who shall determine, I speak it with unfeigned reverence, the number of incompatibilities? But I blush to think it has been neccessary to advocate the cause of the Almighty. Can any one refuse to

> Find tongues in trees, books in the running brooks,
> Sermons in stones, and good in every thing?

"It is a happy world after all," is the glowing language of Paley. "The air, the earth, the water, teem with delighted existence. In a spring noon, or a summer evening, on which ever side I turn my eyes, myriads of happy beings crowd upon my view. The insect youth are on the wing. Swarms of new born flies are trying their pinions in the air. Their sportive motions, their wanton mazes, their gratuitous activity, their continual change of place, without use or purpose, testify their joy and the exultation which they feel in their lately discovered faculties: a *bee* among the flowers in spring is one of the most cheerful objects that can be looked upon. Its life appears to be all enjoyment, so busy, so pleased." "Plants are covered with aphides greedily sucking their juices and constantly, as it should seem, in the act of sucking. It cannot be doubted but that this is a state of gratification." "Other species are *running* which is the same as Bryant's, although founded on different principles.

"The countries bounded on the east and west by the Ganges and the Nile, on the North by the Caspian lake, and the mountainous ridges of Paropamisus and Imaus, and on the south by the Erythræan sea, or Indian ocean, appear to have been the region in which mankind first advanced to civilization. It is highly probable that these countries were the primitive abode of our species, in which alone therefore it can properly be considered as indigenous.

"In the first ages, previous to the origin of the most simple arts, while men were as yet too rude to acquire their sustenance by hunting (or if we receive the scriptural account of the deluge, before the woods were filled with wild animals), they apparently obtained their food chiefly by fishing along the sea shores, or depended for a still more precarious supply on the scanty fruits of the earth. In this state they would of necessity lead a wandering life and extend themselves widely. Different tribes of ichthyophagi or of roaming savages were scattered on each side of the primitive region, wherever an easy progress lay open to them, along the coast or through the woods of Africa, and around the shores of the Indian islands, of New Guinea, and Australasia. The descendants of these dispersed races are still found in the same abodes nearly in their original unimproved condition, savages and negroes, such as we have seen that the stock of their ancestors, the primeval inhabitants of Egypt and India, were.

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about, with an alacrity in their motions, which carries with it every mark of pleasure. Large patches of ground are sometimes half covered with these brisk and sprightly natures. If we look to what the *waters* produce, shoals of the fry of fish frequent the margins of rivers, of lakes, and of the sea itself. These are so happy, that they know not what to do with themselves. Their attitudes, their vivacity, their leaps out of the water, their frolics in it (which I have noticed a thousand times with equal attention and amusement,) all conduce to show their excess of spirits, and are simply the effects of that excess," &c. &c.—Paley, *Natural Theology*, ch. xxvi.

"These were the most ancient colonies which emigrated into the distant parts of the earth. Accordingly they exhibit no affinities with the central nations in their languages, manners, or superstitions. For they went forth when language was as yet imperfectly formed, before manners had acquired any peculiar character, and previous to the age of idolatry.

"The condition of mankind in their primeval seats improved. They became hunters, and afterwards shepherds. Sabaism, or the worship of the heavenly bodies, now prevailed among them. Some tribes of hunters and perhaps of shepherds, ascended the chain of Paropamisus, and spread themselves gradually over the high central plains of Asia, on one side into Siberia and Scandinavia, and on the other into Kamtschatka, and through the adjacent and probably then connected continent of America. These are the Mongoles and other similar races whom we have traced through Asia and the north of Europe, and the primitive inhabitants of the New World. In the languages of these nations, though much diversified and very imperfect in structure, a certain degree of affinity may be clearly marked. In their superstitions, vestiges remain of the primitive Sabaism, even in their more distant settlements. Their physical characters resemble. In other particulars proofs may be collected in many remote regions of the common orgin of these races.

"Meanwhile agriculture was invented in Asia, and the division of labour connected with the institution of casts, which seems to have extended through all the primitive regions, gave a new character to human society. The establishment of a governing or military class, and of a sacerdotal class, gave birth to political order. The priests mingling allegory and fable with the early Sabaism, and with the relics of genuine theism and true historical tradition, which had probably been preserved in a few families, formed a complex system of mythology. The mysteries were invented. Philosophy began to be cultivated, and a more perfect language was formed.

The Celtæ under their Druids, a branch of the eastern hierarchy, advanced into the furthest west, where perhaps some vestiges of previous colonists may be found. They carried with them the mysteries, the doctrine of metempsychosis, the rites of polytheism, the philosophy and the language of the east.

"The Pelasgian and Thracian races established themselves in Asia Minor and passed the Hellespont into Thrace. The former colonized Greece and Italy; the latter passed to the northward of the Danube into the Dacian or Getic country. Tribes of this nation wandered at a later period through the forests of Germany, where they multiplied and encroached upon the Celtæ. Lastly the Medes, delighting in their herds of horses, advanced through the Euxine borders into Scythia and Sarmatia.

"That all these nations, the Celtæ, the Pelasgi, the Goths and the Sarmatæ were comparatively late colonists from Asia, we may safely assert, when we consider the strong affinities discoverable in their systems, in their religious rites and doctrines, and in their dialects which are clearly branches of the Sanscrit and old Persic, and when we remark that most of them may be traced in history still preserved from their primitive settlements in the East."

Our inevitable conclusion thus coincides with the Mosaic account,—that the whole human race is the offspring of the same parents.

THE END.

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